A study of the importance of cultural factors in the user interaction with, and the design of, interactive science and technology exhibits in museums

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A STUDY OF THE IMPORTANCE OF CULTURAL FACTORS
IN THE USER INTERACTION WITH, AND THE DESIGN OF,
INTERACTIVE SCIENCE AND TECHNOLOGY EXHIBITS IN MUSEUMS

by

SUMATH AWSAKULSUTTHI

A Doctoral Thesis
Submitted in partial fulfilment of the requirements for the award of

Doctor of Philosophy
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June 2015

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Abstract
Ph.D.

A STUDY OF THE IMPORTANCE OF CULTURAL FACTORS IN THE USER INTERACTION WITH, AND THE DESIGN OF, INTERACTIVE SCIENCE AND TECHNOLOGY EXHIBITS IN MUSEUMS

Sumath Awsakulsutthi

This research investigates the cultural factors affecting the use of interactive science exhibits including interactive science and technology exhibits (ISTEs) by visitors to science museums worldwide. Visitors bring differing characteristics and experiences to bear upon the task of using these exhibits. These affect the nature and quality of their interaction with the exhibits. This research has focused on the cultural issues, and has defined them using 10 distinct and coherent ‘dimensions’. This has been achieved by extensive review of relevant earlier research work and building on this with experimental studies with visitors and interviews with science museum experts in the UK and Thailand.

Interactive science exhibits now take many forms, and therefore for scientific investigation of their use it is essential to classify them in a form which promotes research validity and reliability. This research has developed a new classification of interactive science exhibits into four classes based upon the user’s perception, cognition and the nature of the interaction. The classes are: (1) simple interaction with direct understanding; (2) simple interaction with complex understanding; (3) multiple interactions with direct understanding; and (4) multiple interactions with complex understanding. This classification was used in experimental studies of interaction with exhibits at science museums. The research methods used mixed methods of quantitative and qualitative research through three separate studies. The data collection methods were: interviews, questionnaires, and video recording observation. The findings were that not only language issues and conceptual understanding are important factors, but other cultural factors were also inter-related and affect visitors’ learning through ISTEs.

Keywords:
science museum, science centre, culture, interactive science exhibit
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Firstly, I would like to acknowledge the assistance of my supervisors - Nigel Zanker and Andrew May. They assisted me in developing the thesis structure and proof-reading this thesis. I would like to thank Sarah Turner, an independent assessor who advised concerning my academic writing and Professor Catherine McDermott from the Kingston University who was invited to be my external examiner. In addition, I would also like to thank Professor Tracy Bhamra, and the staff in Loughborough Design School for all their support.

Also I would like to acknowledge with much gratitude the support of my sponsor, the Ministry of Science and Technology (MOST), a part of the Royal Thai government which has supported my scholarship. Without its support this PhD would not have been possible. In addition, I would like to thank Mr. Manop Issaree, Vice President of the National Science Museum (NSM) of Thailand who has continuously encouraged me to study at PhD level. Also I thank my colleagues at the NSM who have sent me many photos of the interactive science exhibits from the NSM in support of my research and this thesis, including Mr. Malcolm F. Bray, Ms. Umaporn Kruekamwang, and Mr. Narongsak Sukaram. I am also grateful to Mrs. Aparat Tintabootr who has helped me organise my personal Thai tax documents during my PhD study in the UK. Also I would like to acknowledge the support and assistance given me by David Davies, the former executive director of HUSAT at Loughborough University.

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museum which was written by Kirby et al. (2011). Thanks to the PGCE students from Loughborough Design School for completing the survey of interactive science and technology exhibits, and Christiane Cunnar at Yale University who introduced the website of Human Relations Area Files (HRAF) of World Cultures & Archaeology.

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Dedication

To my parents, Sui and Naikim Awsakulsutthi, who always supported and encouraged me throughout every stage of my life.

I also would like to great thank for my four elder sisters – Wimonlak (Sunee), Sunanth, Supa, Suda - and two elder brothers - Suporn and Supot - who advised me with love and sincerely. And to Ms Kanchana Sripangsan and her family have continually supported and counselled me. There is no doubt in my mind that without their sincere love and support from all of these persons who live in Thailand, I would not have been able to achieve my academic accomplishments over the years.

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<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D</td>
<td>Three Dimensions</td>
</tr>
<tr>
<td>ASDC</td>
<td>The UK Association for Science and Discovery Centres</td>
</tr>
<tr>
<td>ASPAC</td>
<td>Asia Pacific Network of Science &amp; Technology Centres</td>
</tr>
<tr>
<td>ASTC</td>
<td>Association of Science - Technology Centers Incorporated</td>
</tr>
<tr>
<td>BBC</td>
<td>British Broadcasting Corporation</td>
</tr>
<tr>
<td>BCLM</td>
<td>Black Country Living Museum</td>
</tr>
<tr>
<td>BIS</td>
<td>The Department for Business, Innovation &amp; Skills</td>
</tr>
<tr>
<td>BOS</td>
<td>Bristol Online Surveys</td>
</tr>
<tr>
<td>Ecsite</td>
<td>European network of science centres and museums</td>
</tr>
<tr>
<td>e-journal</td>
<td>Electronic journal</td>
</tr>
<tr>
<td>Estonian SSR</td>
<td>Estonian Soviet Socialist Republic</td>
</tr>
<tr>
<td>F</td>
<td>Female</td>
</tr>
<tr>
<td>HCI</td>
<td>Human-Computer Interaction</td>
</tr>
<tr>
<td>HMNS</td>
<td>Houston Museum of Nature and Science</td>
</tr>
<tr>
<td>HUSAT</td>
<td>Human Sciences and Advanced Technology Research Institute</td>
</tr>
<tr>
<td>IAR</td>
<td>Instructional Assessment Resources</td>
</tr>
<tr>
<td>IBM</td>
<td>International Business Machines</td>
</tr>
<tr>
<td>IQ</td>
<td>Intelligence Quotient</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>ISTE</td>
<td>Interactive Science and Technology Exhibit</td>
</tr>
</tbody>
</table>
LDS = Loughborough Design School
M = Male
MA = Master of Arts
MLA = Museums, Libraries, and Archives Council, UK
MOSI in the UK = Museum of Science and Industrial at Manchester city, UK
MOSI in the USA = Museum of Science and Industry, USA.
MOST = Ministry of Science and Technology (MOST) under the Royal Thai government
N/A = No answer or Not applicable
NISE = Nanoscale Information Science Education
NMNS = National Museum of Natural Science, Taiwan
NSC = National Space Centre, UK
NSM = National Science Museum, Thailand
OCLC = ‘Online Computer Library Center, Inc’, USA
PGCE = Professional Graduate Certificate of Education, or Postgraduate Certificate of Education
PhD = Doctor of Philosophy
RQ = Research Question
SAR = Special Administrative Region
sec.clip = seconds clip
SIM = Spaceflight Induction Module
SPSS = Statistical Package for the Social Sciences
STEM = Science, Technology, Engineering and Mathematics
TCNJ = The College of New Jersey
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>UCD</td>
<td>User-Centred Design</td>
</tr>
<tr>
<td>UNESCO</td>
<td>United Nations Educational, Scientific and Cultural Organization</td>
</tr>
<tr>
<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
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Chapter 1
Introduction

1.1 Introduction

The first chapter of this thesis sets out the rationale for the topic chosen. It makes the case for new knowledge which can influence future developments in the dissemination of scientific knowledge, through inputs to the design and operation of interactive science exhibits in museums and science centres.

First, the aim and objectives of the study are introduced. Second, the research agenda is described comprising of the literature review, the research structure, and the data gathering strategy. Third, the aim of the research is stated and how this is to be achieved by means of the research strategy, research questions and research to be conducted. The overall aim is to understand the cultural issues which affect the dissemination of scientific knowledge through the use of interactive science and technology exhibits.

The research questions relating to this thesis are shown in Table 1.1.

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<th>Research questions of the enquiry:</th>
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<td>RQ 6</td>
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<td>RQ 7</td>
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<tr>
<td>RQ 8</td>
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</tbody>
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Table 1.1: Research questions in this thesis
1.2 Personal motivations
The author, Sumath Awsakulsutthi, graduated with a Bachelor of Science degree in Physics in March 16, 1996 from Kasetsart University, Bangkhen Campus in Bangkok of Thailand and worked as a science educator at the National Science Museum (NSM), Thailand. After more than 10 years spent developing exhibits and training volunteers at the museum, the author realised that his personal knowledge, and the knowledge and expertise of organisations, needed to catch up with the increasingly rapid developments in new technology. To that end, the author applied to the University of Leeds to study for a Master of Arts degree in ‘Science Education’, with a Scholarship provided by the Ministry of Science and Technology for the Royal Thai Government. He successfully completed this course on the 30th September 2009.

The Masters course highlighted the lack of university research where the aim was to understand the uses of new technology in disseminating information, providing education functions and their potential for application to science museums, centres, and discovery centres sector. The author had formed a view during the Masters course that there was limited research and insight into the impact of national regional and continental factors in the provision design and operation of new technologies in this sector.

Considering these facts, he decided to seek an opportunity to investigate these matters in an appropriate research context, and to seek supporting funding. For the second time, the Royal Thai Government provided financial support for his PhD study at Loughborough University.

1.3 Background of the research programme
This research follows on from research conducted by the author on his Master’s course supported by a scholarship from the Royal Thai Government. The formation of this research topic was stimulated by the following sections:
1.3.1 The initiated research topic
The chosen research topic was ‘A study of the importance of cultural factors in the user interaction with, and the design of, interactive science and technology exhibits in museums’. It considered particular exhibits which were interactive science and/or technology exhibits. In addition, interactive science exhibits sometimes are referred to as ‘hands-on’ (Caulton, 1998; Gutwill, 2008; Horn et al., 2012; Humphrey et al., 2005; Ramsay, 1999; Thomas, 1994; Tokar, 2004; Walker, 2008) or ‘multisensory exhibits’ (Allen, 2004; Eldridge, 1995; Piscitelli et al., 2003; Tokar, 2004).

Caulton (1998, p.1) remarked that “However, as the twentieth century draws to a close, many new exhibitions are designed exclusively which hands-on exhibits, whilst many more incorporate hands-on exhibits within traditional exhibits or in galleries utilising a mixed range of interpretative media”.

The research topic for this thesis came from the field study part of the MA Science Education which the author studied in 2009 at the University of Leeds. This research was conducted during the dissertation in the final year of the MA with the aim of understanding and learning through interactive science and technology exhibits. The Museum of Science and Industrial at Manchester city (MOSI) was the target organisation as a principal case study in the MA Science Education.

1.4 Research agenda
An outline of the research is described under the following headings.

► Literature review
► Research structure
► Data gathering strategy

1.4.1 Literature review
The literature review provided the principal direction for the research. It informed the formation of the research questions and guided the development of the questionnaire sent to experts in science museums and centres. It guided the definition of the methods to be used in the observation
and investigation of interactive science and technology exhibits. The review gave rise to the concepts of interaction in design and the classification of interactive science exhibits. These were critical to understanding the fundamentals of interactive science exhibits and the particular importance of the perception of culture, cultural, and cultural differences. Several categories of publication were reviewed such as journals, books, theses, dissertations, conference papers, e-journals, websites, and online news.

1.4.2 Research structure
Trochim and Donnelly (2008) stated that the ‘hourglass model’ was commonly used to create a structure for intended research. This model for the generation of a structure of research is called by other names, such as the “hourglass research model” (Murchison, 2010, p.212), “The ‘hourglass’ notion of research” (Trochim, 2006b, para 1), and “an hourglass shape” (Yin, 2011, p.267). Alasuutari (1996, p.374) pointed out “That is why the research process could be depicted in the shape of an hourglass. One starts out with a rather broad theoretical and structural framework that places a particular research site in a large context and that also validates the choice of that particular case study.”

The research structure of this thesis was based on the ‘hourglass model’, shown in Figure 1.1.

![Image](https://example.com/figure1.png)

**Figure 1.1: Illustrated ideal model of a research structure**
[Modified by the author from a diagram of Trochim (2001, p.15)]
1.4.3 Data gathering strategy
This research involved a range of people who relate to interactive science exhibits. These groups were:

- the members of science museums, science centres, and science discovery centres such as science educators, curators, staffs and volunteers
- exhibit designers
- local and international visitors
- researchers

Figure 1.2 shows these groups, as a conceptual diagram of the interactive science exhibits research.

![Conceptual diagram of interactive science and technology exhibits research](image)

**Figure 1.2: Conceptual diagram of interactive science and technology exhibits research**

This conceptual diagram of interactive science and technology exhibits (ISTEs) represents visitors, science educators and exhibit designers. The literature review of this research e.g. Macdonald (2007), showed that the
exhibit designers should develop a direct link with exhibits to bridge between the interaction designs and various cultural issues relating to local and international visitors. The educators of science museums and science centres should effectively transfer the scientific knowledge taking into account the cultural differences between local visitors and international visitors.

Current developments of interactive science and technology exhibits in taking cultural influences into account vary considerably across the various groups involved and across countries. The groups consist of researchers, science educators, exhibit designers, local and international visitors. Each group might need to consider cultural influences in the same way or in different ways. This research attempts to plug the gap of understanding of the cultural issues and the implications for exhibit design. To that end prototype guidelines have been developed for use in the design, development, and operation of ISTEs. These are presented in Chapter 8 of this thesis.

1.5 Aim of the research
The overall aim is to understand the cultural issues which affect the dissemination of scientific knowledge through the use of interactive science and technology exhibits. The aim of the research is stated and summarised under two headings, research strategy and research conducted.

1.5.1 Research strategy
The research strategy contains two major components. The first component is an analysis of the existing classifications of interactive science and technology exhibits (ISTEs). The method used was cluster analysis for identifying a new classification of ISTEs based on Simons’ (2010) thesis. The second component is an investigation into the dimensions of the cultural issues and their relationship to interactive science and technology exhibits.

The analysis from the classifications were identified and clustered. A new group of ISTEs were found after the cluster analysis was conducted and a new classification was generated. This consisted of 10 dimensions of cultural
issues was which was established and developed from the process of reviewing the literature.

The two main empirical results were brought together in order to establish common findings. The results of the new classification and the findings in relation to the dimensions of the cultural issues were joined together.

1.5.2 Research conducted
The following table shows how the research was conducted for each research question, shown in Table 1.2.

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Research conducted</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ 1 What is culture, and what is the meaning of cultural differences?</td>
<td>Literature review: ▶ Reviewed from several sources such as books, book sections, journal articles, conference papers, dictionary entries, theses, web pages, reports, newspaper articles, and magazine articles.</td>
</tr>
<tr>
<td>RQ 2 What is meant by interaction, and what is an interactive science and technology exhibit?</td>
<td>Literature review: ▶ Reviewed from several sources, the same as for RQ1.</td>
</tr>
<tr>
<td>RQ 3 Why is the classification of interactive science and technology exhibits so important for today and the future; and what classifications are there?</td>
<td>Literature review: ▶ Reviewed from several sources, the same as for RQ1 and RQ2.</td>
</tr>
</tbody>
</table>
| RQ 4 How to define the relation between the cultural differences and interactive science and technology exhibits, and what categories of cultural differences are there? | Literature review: ▶ Reviewed from several sources the same as for RQ1-RQ3.  
Case study 1: ▶ Cluster analysis for evaluating the existing classifications of interactive science exhibits.  
▶ Reliability was assessed using inter-rater reliability.  
▶ Paper-based questionnaire using the new classification and the cultural issues relating to interactive science exhibits.  
▶ Interviews were conducted with a few experts of the museums of science. |
<p>| RQ 5 What interest have the experts of the museums of science in culture influencing the use of interactive science and technology exhibits; and which cultural issues do they believe are the most important? | Literature review: ▶ Reviewed from several sources - e.g. academic journals, books, conference paper and web pages - which present interaction designs relating to culture and cultural differences. |</p>
<table>
<thead>
<tr>
<th>RQ 6</th>
<th>How do the characteristics of the interactive science and technology exhibit take account of cultural differences which affect learning?</th>
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<tbody>
<tr>
<td></td>
<td><strong>Case study 2:</strong></td>
</tr>
<tr>
<td></td>
<td>► Network analysis to identify grouping of the cultural issues relating to interaction designs in term of dimensions.</td>
</tr>
<tr>
<td></td>
<td>► Validity at the science museums and identify the cultural issues relating to interaction designs in the literature review of RQ3.</td>
</tr>
<tr>
<td></td>
<td>► Online questionnaire sent to the science museums in many countries around the world.</td>
</tr>
<tr>
<td></td>
<td><strong>Literature review:</strong></td>
</tr>
<tr>
<td></td>
<td>► Reviewed from several sources e.g. academic journals, books, conference papers and web pages.</td>
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<tr>
<td></td>
<td><strong>Case study 3:</strong></td>
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<tr>
<td></td>
<td>► Paper-based questionnaire was undertaken by visitors at the National Space Centre in the UK.</td>
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<td></td>
<td>► Video recording, conducted by observation of visitors interacting with the existing interactive science exhibits.</td>
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<table>
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<tr>
<th>RQ 7</th>
<th>What are other factors which significantly contribute to cultural differences in learning to use and using interactive science and technology exhibits? For example, age, gender, and educational levels. Why are these factors related?</th>
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<tr>
<td></td>
<td><strong>Literature review:</strong></td>
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<tr>
<td></td>
<td>► Reviewed from several sources e.g. academic journals, books, conference papers and web pages.</td>
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<td></td>
<td><strong>Discussion:</strong></td>
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<tr>
<td></td>
<td>► Results from the case studies – e.g. case study 1, case study 2, and case study 3 – used to evaluate these factors.</td>
</tr>
<tr>
<td></td>
<td>► The model of the cultural issues relating to the new classification of ISTEIs explored to correlate with the results in case study 1, 2, and 3.</td>
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<tr>
<td></td>
<td>► Design guidelines of interactive science and technology exhibits will be offered in a form of check lists.</td>
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<th>RQ 8</th>
<th>How can interactive science and technology exhibits be developed to capitalise more successfully on cultural differences?</th>
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<td></td>
<td><strong>Literature review:</strong></td>
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<tr>
<td></td>
<td>► Reviewed from academic sources</td>
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<td></td>
<td><strong>Conclusion:</strong></td>
</tr>
<tr>
<td></td>
<td>► Reporting the knowledge of this thesis which can be applied to develop ISTEIs taking account of the cultural issues or the nature of cultural differences.</td>
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<tr>
<td></td>
<td>► Limited research relating to these factors will be described which may be important to further study in the future of other researchers.</td>
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**Table 1.2: Research questions relating to the research conducted**
1.6 Overview of the thesis

This thesis is structured into nine chapters. The overview of each chapter is as follows:

Chapter 1 - Introduction

This chapter introduces the research topic, explains the personal motivations and provides background from the wider research programme. It outlines the thesis and describes the aim and objectives of the research, the research strategy and overview of the thesis.

Chapter 2 - Literature review

Chapter 2 provides definitions of ‘culture’ and ‘cultural’, which relate to the meanings of ‘cultural differences’. The dimensions of general cultural models are clarified.

It reviews literature focusing on the interactive science and technology exhibits (ISTEs). It shows the importance and relevance of science and technology to the many worldwidescience museums developing interactive science exhibits.

Chapter 3 - Research methodology

Chapter 3 provides an overall plan of the research methodology. Several research methods are contained in this chapter such as the method of triangulation, the method of cluster analysis, and the method of survey. The research study is divided into three case studies. It describes which case studies are used to address which research questions.

Chapter 4 - Case study 1: Exploring the cultural issues and classifying interactive science and technology exhibits

Chapter 4 describes case study 1. This study consists of the five main elements of the study.

(1) The cultural difference relating to ISTEs were explored by revising a previous MA study conducted by the author.

(2) The existing classifications of ISTEs were identified.
(3) A new classification of ISTEs was developed in a process of categorisation such as reliability (Likert-scale, inter-rater reliability), and qualitative analysis (cluster analysis).

(4) A paper-based questionnaire of ISTEs’ classifications and the dimensions of cultural issues was designed.

(5) The expert interviews were reported from Snibston and the NSM in Thailand.

Chapter 5 - Case study 2: The 10 dimensions of the cultural issues
Chapter 5 reports case study 2 addressing the cultural issues. The main study comprised the three main processes.

(1) The literature review to collect additional dimensions of cultural issues relating to interaction designs. A network analysis to identify the groups of these cultural issues in term of their dimensions.

(2) The validation at the museums of science using observation by the author and review the literature of culture relating to interaction designs.

(3) Web-based questionnaires sent to several types of experts at science museums of around the world. Stages of the online questionnaire were processed through searching websites, collecting email contacts list, sending the online survey and evaluating data analysis.

Chapter 6 - Case study 3: Language issues and conceptual understanding
Chapter 6 reports case study 3 with the two key cultural issues - namely language issues and conceptual understanding. The main study comprised of three elements:

(1) A paper-based questionnaire

(2) Developing a criteria using Rubric scales for the questionnaire evaluation

(3) Video recording of observations.

Chapter 7 - Discussions
Chapter 7 discusses the new classification of interactive science and technology exhibits (ISTEs) integrating the validated 10 dimensions of
cultural issues from case studies 1, 2 and 3. An overall new classification correlating these cultural issues was derived that may be useful for application by any science museum. In particular, the cultural issues relating to interactive science exhibits are explored with regards to other factors such as age, gender, and educational. Design guidelines are discussed.

**Chapter 8 - Conclusions and Design Guidelines**

Chapter 8 summarise what has been found out in relation to knowledge of cultural issues and its influence on science museums around the world.

Recommendations for future work indicate how essential cultural differences influence the infrastructure of interactive science and technology exhibits. Chapter 8 presents guidelines for designing interactive science exhibits, categorised under each of the 10 cultural factors.

A model of the thesis structure is provided in Figure 1.3. It shows the correlation between the research questions and the chapters which they address, to clarify the main research topic.
Figure 1.3: The model of thesis structure
Chapter 2
Literature review

2.1 Introduction

Chapter 2 provides a review of the literature with the focus on a definition of culture, of specific relevance to the meaning of cultural differences. Essential explanations are about interaction and interactive science exhibits in order to understand their meaning. Previous classifications of interactive science exhibits of several researchers were updated. Additionally, culture relating to interaction was categorised in terms of dimensions, and reviewed to prepare for investigating interactive science and technology exhibits. The research questions relating to this chapter are shown in Table 2.1.

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<th>Research questions of the enquiry:</th>
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<td>RQ 7</td>
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<td>RQ 8</td>
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Table 2.1: Research questions in chapter 2
2.2 Aims and objectives

The topic of this research is ‘A study of the importance of cultural factors in the user interaction with, and the design of, interactive science and technology exhibits in museums’. The overall aim of this chapter is to define the essential words which relate to the research topic such as culture, cultural, interaction, interactive science exhibit, and interactive science and technology exhibit. In a little more detail, the objectives of this chapter are to:

► Describe the meanings of several words which incorporate forms of the word culture such as culture, cultural, and cultural differences.
► Outline the dimensions of general cultural models which were found from other researchers.
► Describe background information relating to museums of science.
► Provide the definitions of interaction, interactive science exhibit, and interactive science and technology exhibit, and existing design guidelines.
► Outline the classifications of interactive science exhibits which were developed by other researchers.
► Describe the relation between culture and science education.
► Outline the 10 dimensions of cultural issues relating to interaction design.

2.3 The definitions of culture and cultural

The earliest meaning of culture was ‘cultivation’ by the Middle Ages and its meaning had changed to ‘development of heart’ (Sakamoto, 2003).

“... the concept of culture was first defined in print in 1871 by E.B. Tylor, after all these years it still lacks the rigorous specificity which characterises many less revolutionary and useful ideas” (Hall, 1959, p.43). The original definition of culture of Tylor (1871, p.1) meant as “Culture, or civilization, taken in its broad, ethnographic sense, is that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society”.
However, the concept of culture is presently wider to cover several subjects of human’s involvement rather than the Tylor’s (1871) definition.

“The word ‘culture’ comes from the Latin root ‘colere’ (to inhabit, to cultivate, or to honor)” (Zhu, 2010, p.226). Also Sakamoto (2003) referred to the academic work of Tanase (1959) that the meaning of culture significantly changed over time. For example, in the 20th century the foremost meaning of culture was ‘mode of life in the respective social groups’. Compared with the 18th and the 19th century, the definition of culture became a ‘sophisticated way of life’.

In this thesis, the word ‘Culture’ is defined as an overall term for a shared way of life through art, artefacts, attitudes, beliefs, cities, customs, languages, social behaviour, and social organisation in a group or particular country (Cambridge Dictionaries Online, 2012b; Longman dictionary of contemporary English, 2003c; Oxford Advanced Learner’s Dictionary, 2013a). This includes technologies which humans have created over the centuries (Hughes, 2005; Walker and Chaplin, 1997).

“Culture is the collective programming of the mind that distinguishes the members of one group or category of people from others” (Hofstede, 2012, para.1).

Furthermore, Buchanan (1998) pointed out that culture was an essential exploration of people in everyday life and involved art, politics, science, and design. Also culture influenced the actions of human engagements such as ordering, disordering, and reordering to explore understanding. In recent years, culture has also come to include information systems and their use in passing on knowledge to succeeding generation (Matsumoto, 2007; Matsumoto and Juang, 2007).

International organisations have also generated their definitions of culture. For example, UNESCO (2001, para.1) offered their definition of culture:

“the set of distinctive spiritual, material, intellectual and emotional features of society or a social group, and that it encompasses, in addition to art and
literature, lifestyles, ways of living together, value systems, traditions and beliefs.”

For instance, “Walking in step is no mere cultural curiosity, but is an important index to a whole way of life which stresses regularity of behavior of the 'keep in line' and 'be on time' variety” (Embree, 1950, p.183). However, Embree (1950) remarked that some people might disagree because they believe that ‘keep in line’ and ‘be on time’ were personal characteristics more than characteristics of particular cultures. In addition, UNESCO's (2009) Framework for Cultural Statistics pointed out that the beliefs and values of a society or a social group were used to measure and investigate the definition of culture which came from the results of behaviour and practice in that society.

The word ‘cultural’ is an adjective which is a descriptive word. It is related to the culture, arts of the society, habits, beliefs and traditions of the society e.g. cultural achievements, cultural differences, cultural context, cultural background, cultural heritage, cultural life, cultural centre and cultural activities (Cambridge Dictionaries Online, 2012a; Longman dictionary of contemporary English, 2003b; Compact Oxford Dictionary & Thesaurus, 2009b). However, Hofstede (2001) suggested that culture might refer to national culture which is the same as national character in earlier terms. National culture was studied particularly for a specific number of countries to determine their cultural relativism. He indicated that cultural relativism was involved with cultural differences between human beings in groups and societies who acted differently in their activities, and had differing emotions and thoughts.

Further, every country in the world may have their own definition of the words ‘culture’ and ‘cultural’ in their own languages though they may have similar meanings. For example, the word ‘Watthanatham’ in Thai language is a complex word to translate a mixture of culture and cultural from the English language. ‘Watthanatham’ defines the way of life as one which comprises all viewpoints of social life and that has more opportunities for changing to good activities from bad activities (Aasen, 1998; Rama9art, 2012). An example is
that of the Thai people in the South of Thailand who speak in the same
dialect, enjoy eating spicy food, and wear the same styles of their traditional
costumes (Johnson, 2002). In addition, ‘Watthanatham, as an equivalent of
the German term 'bildung' and perhaps the English term 'high culture', is a
quality inherent in a well-developed, advanced civilization. It, unlike
‘vernacular culture’ or the German ‘kultur’, increases with prosperity”
(Johnson, 2008, p.16). Hence, the definition of culture as ‘Watthanatham’ in
the Thai language is more complex than the Western definition.

The various meanings of culture in different cultural groups means that
people from other countries perceive their meaning of the word ‘culture’ as
different to the meaning of the word in the English language. For example,
Hall (1959) who is an American anthropologist, significantly compared the
perception of the periods of time between the Western culture and the South
Asian culture. He said that “For us a ‘long time’ can be almost anything -- ten
or twenty years, two or three months, a few weeks, or even a couple of days.
The South Asian, however, feels that it is perfectly realistic to think of a ‘long
time’ in terms of thousands of years or even an endless period” (Hall, 1959,
p.30).

To summarise, ‘culture’ is defined as ‘an overall term for a shared way of life
… in a group or particular country’. This definition relates to visitors in society
who may comprise of both local and international visitors and have their own
culture.

2.4 The meaning of ‘cultural differences’

“Every culture distinguishes itself from others by the specific solutions it
chooses to certain problems which reveal themselves as dilemmas”
(Trompenaars and Hampden-Turner, 1997, p.8). This definition of cultural
differences was based on three factors which were related to: other persons,
time orientations, and environments. Additionally, Trompenaars and
Hampden-Turner (1997) proposed a mechanism where these solutions of
different cultures induced the underlying cultural dimensions. As an example
definition of cultural differences, Serpell (1976, p.55) remarked that,
“Not only is language widely regarded as man’s most distinctive behavioural characteristic within the animal kingdom, but it is also a widely recognised distinguishing characteristic for different cultures”. His statement asserts that language was being accepted as a common feature for the study of different cultures.

Laroche (2008) claimed that similar gestures in different cultures did not have the same meaning in the different countries e.g. a gesture of ‘OK’ in Canada was a very impolite gesture in Brazil and Russia. On the other hand, that ‘OK’ gesture meant ‘zero’ in France, and signified ‘money’ in Japan. Furthermore, Brislin (1993) asserted that taking care of unhealthy old people, selecting a marriage partner, bringing up children and helping with the protection and safety of children appeared as essential activities in different cultures.

2.5 The dimensions of general cultural models

Hofstede (2001, p.1) stated that, “The concept of dimensions of culture is introduced through an inquiry into the philosophical opposition between the specific and the general, the different and the similar”. However, it was said that Hofstede’s (2001) statement focused on the comparative criteria of cultures such as different cultures, similar cultures, specific cultures and general cultures, giving an unbalanced view.

The existing models of culture are expressed as distinctive lists of general cultures in the world. The cultural models were classified by many researchers such as Hall (1959), Hofstede (2001), Trompenaars (1993), and Victor (1992). Additionally, the cultural models of Hall (1959) and Trompenaars (1993) were republished in the further edition of book with their colleague as Hall and Hall (1990), and Trompenaars and Hampden-Turner (1997). These cultural models and dimensions help to generate to a particular focus on culture. These were presented by Marcus and Baumgartner (2004), and Ford et al. (2005) which help to provide a particular focus on culture. The various dimensions of cultural models are shown in Table 2.2.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Cultural models</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hall (1959), Hall and Hall (1990)</td>
<td>Speed of messages</td>
<td>“Culture is communication and communication is culture. … Culture is concerned more with messages than it is with networks and control systems” (Hall, 1959, p.217). Different cultures have various paces and frequency of accepting messages hence people should be familiar with the speed of messages in their cultures. For example, Americans clearly understood the information from the short and fast messages on the television advertisements in their country (Hall, 1959).</td>
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<tr>
<td></td>
<td>Context</td>
<td>Context was defined by Hall (1959) as the information encompassing an event. Hall (1959) divided the context into two levels which were low context and high context. A low context for communication occurs for most information which people spoke to each other with direct and explicit messages. Hall (1959) said that low-context cultures might often be used to rely on facts and logic rather than intuitive guess by people who had German, North American and North European backgrounds. While a high context communication occurs where the internal meaning of information contained in the messages is complex. Nevertheless, when the high context was communicated as interpersonal relationship styles, the speakers could interrupt each other. Because they speak using more indirect messages in a linear way, including facial expression, tone of voice, and gestures. For example, high-context cultures were frequently used by Japanese, Chinese, Korean, Greek, Arab and Italian (Hall, 1959).</td>
</tr>
<tr>
<td></td>
<td>Space</td>
<td>The word ‘space’ (or territoriality) was used to define a place or area of things. For example, rich and poor people should equally queue up for services in American culture (Hall, 1959).</td>
</tr>
<tr>
<td>Hall (1959), Hall and Hall (1990) [continued]</td>
<td>Time</td>
<td>“Time may indicate the importance of the occasion as well as on what level an interaction between persons is to take place” (Hall, 1959, p.24). If someone was called early morning in USA, the time of the call may be used as signals of the emergency topic. The experience of time would vary depending on people's experience. For instance, any period which was spent on an activity for more than a week might be regarded as too long in Middle Eastern society. In addition, Hall (1959) classified time as in two types. The first type, ‘polychronic time’ was multiple events in loops at the same time. The second type, ‘monochronic time’ was described as an event occurring linearly in time (Hall, 1959).</td>
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<tr>
<td></td>
<td>Information flow</td>
<td>Information flow was defined by Hall and Hall (1990, p.22) as “… a message intended to produce an action to travel from one part of an organization to another and for that message to release the desired response. Cultural differences in information flow are often the greatest stumbling blocks to international understanding”. The information flows in most private offices in the USA were slow. Because the messages from the manager were passed through a secretary who might not share all the information with the chiefs of departments and other officers (Hall and Hall, 1990).</td>
</tr>
<tr>
<td></td>
<td>Action chains</td>
<td>Action chains were defined as serial events leading to a defined achievement. One or more persons could participate in action chains. Greeting people such as shaking hands and training people were examples of action chains in Western business (Hall, 1990).</td>
</tr>
<tr>
<td>Hofstede (2001)</td>
<td>Power distance</td>
<td>It was defined as “the extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally” (Hofstede, 2001, p.98). Power distance was linked between the various solutions and fundamental dilemmas</td>
</tr>
</tbody>
</table>
of unfairness and fairness. The less powerful members within a culture accept the majority effective of equality and inequality. The two different sides of the members were low and high power distance.

Further, Hofstede (2001) gave the examples of low power distance such as freedom which was more important than equality; top leaders were younger and middle age started after 40 years old. On the contrary, high power distance was shown as equality was more important than freedom, top leaders were older and the middle age started before 40 years old.

<table>
<thead>
<tr>
<th>Hofstede (2001) [continued]</th>
<th>Masculinity vs. femininity</th>
<th>It defined the gender roles and emotional roles between men and women such as gender differences, education occupation, personal time and physical conditions (Hofstede, 2001).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individualism vs. collectivism</td>
<td>It related to the characters of the individual person and the group. Hofstede (2001) explained the relationship between individualism and collectivism in the societies, “It is reflected in the way people live together – for example, in nuclear families, extended families, or tribes – and it has many implications for values and behaviour”. (Hofstede, 2001, p.209)</td>
<td></td>
</tr>
<tr>
<td>Uncertainty avoidance</td>
<td>It was defined as the suffering or anxiety of risk event when people were confronted in society by unpredictability. Hofstede (2001) suggested that technology, rules/laws and rituals/religion could be applied to manage the uncertainty avoidance. For example, people in cultures in strong or high uncertainty avoidance work following more rules, compared with people with cultures in weak or low uncertainty avoidance expect more relaxed lifestyles and have more practical activities than activities involving theoretical considerations.</td>
<td></td>
</tr>
<tr>
<td>Author(s)</td>
<td>Method</td>
<td>Description</td>
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<tr>
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</tr>
<tr>
<td>Hofstede (2001)</td>
<td>Time orientation</td>
<td>Short-term orientation and long-term orientation of people attitudes to life and its necessary activities are conditioned by their thinking about time. Short term thinking may deal with the needs of today and tomorrow, but does not address longer term issues. Planning is an essential prerequisite for considering long term issues. For example, the short-term orientation cultures were chosen using the values of the present and past such as respect for tradition, personal stability and preservation of face. While the long-term orientation cultures were found using the values of the future such as having a sense of shame, frugality and perseverance.</td>
</tr>
<tr>
<td>Trompenaars, Trompenaars and Hampden-Turner (1997)</td>
<td>Universalism vs. particularism</td>
<td>Universalism defined as the standard for most people who believed or agreed with good ways such as not to cheat or lie. For example, people could cross the road when the red traffic light was illuminated as a basic rule of universalist in Germany or Switzerland. On the other hand, particularism which applied to a person who had special authority and discretion over the rules. In this case, people could not rely on him because he always used his discretion to favour his close friends only.</td>
</tr>
<tr>
<td>Neutral or emotional</td>
<td>The direct emotional or neutral responses were shown in relationships between people. For example, people in other cultures might have different feelings from each other on some events at work. Some people might feel upset or some may feel neutral. Furthermore, people might be willing to acquiesce at the emotion of others because of their relationships or connections. Trompenaars (1993, p.71) remarked about an indirect response that “Because I agree with your reasoning or proposition, I give you my support”.</td>
<td></td>
</tr>
<tr>
<td>Individualism vs. collectivism</td>
<td>Individualism is defined as a characteristic of modern society that enabled innovations in critical developmental periods such as the Renaissance, the industrial revolution in the UK and the French</td>
<td></td>
</tr>
</tbody>
</table>
| **Trompenaars (1993),**  
| **Trompenaars and Hampden-Turner (1997) [continued]** | Enlightenment. However, the individualistic cultures, 'I' was used as personal accountability and lone achievement.  

The original word for collectivism that was 'communitarianism' used by Trompenaars (1993). The communitarian cultures existed amongst groups of people and they preferred to use 'We'. For example, Trompenaars and Hampden-Turner (1997, p.60) explained that “If you arrive unaccompanied in Thailand, they may seriously underestimate your status and power at home”. He pointed out that most Thai people might believe that someone who came alone into another country might not have any close friends. However, no Thai people would like to be a friend of that lonely person. |
<p>| <strong>Specific vs. diffuse</strong> | Specific cultures were separated from the public space or public life and defined as small areas. In contrast, the diffuse cultures were defined as large private spaces. For example, “For him, a refrigerator was my public space into which I had invited him…To me, a car was certainly private space. Have you ever tried to borrow a German acquaintance’s Mercedes?” (Trompenaars, 1993, p.83) |
| <strong>Achievement vs. ascription</strong> | Achievement culture was defined as the group of people who could succeed by their own strenuous efforts, which were predominantly young, and often succeed in education and business. In the ascriptive culture, promotion would take place steadily over time as their seniority increased. Hence, the achieve team must understand some ascriptive team in other cultures (Trompenaars, 1993). For example, most Japanese people believed that “Older people are held to be important so that they will be nourished and sustained by others’ respect” (Trompenaars and Hampden-Turner, 1997, p.109). |
| Time | The concept of time was increasingly complex for management of the nature of human existence. Trompenaars (1993, p.121) noted that “Time has meaning not just to individuals but to whole groups or cultures”. For instance, Italians prefer to regard time as linked to the activity which they are engaged in more than the time on the clock face. In contrast Americans and Germans might follow the time on the clock. |
| Environment | Natural environments and natural elements surround human existence such as fire, floods, forest, river, and wind. Nature presented two main orientations of culture. The first orientation believes that they can accept that nature did the best it could. It must follow as part of nature and therefore is inner-directed. Similarly as an organization or a machine must go along the path of its controllers. The second orientation admits that it is worth controlling the natural forces such as weather and rivers. Like an organization which is itself a product of nature and it seeks to find a suitable ecological balance. It is called as outer-directed. |
| Language | Language must be shared as a common language in a culture to transfer effective meaning between organisations. A variety of languages might cause problems in associations of multinational organizations. Problems could include slow interactions and development of relationships, incorrect translation and misconception of information. |
| Environment and technology | The environment tends to operate by using technology from a cultural perspective. Technology could be used and developed in other cultures where appropriate adaptation could take place through communication strategies. |
| Social organisation | Social organisations were established to support the structures and organizations of each culture. The social values of the culture were used by the organizations. In addition, the gender roles and |</p>
<table>
<thead>
<tr>
<th>Author</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Victor (1992)</td>
<td>Individual or group targets were also integrated in the social constructions. For example, the values-building social organizations appeared in education structures, family systems, occupational organisations, judicial and political institutions.</td>
</tr>
<tr>
<td>Contexting</td>
<td>Contexting was defined as “the way in which one communicates and especially the circumstances surrounding that communication” (Borisoff and Victor, 1989, p.140). Contexting was divided into two categories such as low and high context. Differences in contexting found in cross cultures generated various resulting behaviour such as reliance on verbal conversation, belief in obvious communication/ law/ commitment, and encouragement of personal relationships.</td>
</tr>
<tr>
<td>Authority conception</td>
<td>An authority conception meant that the authority in society was viewed in a different perspective in different cultures. For example, the power, power distance, the leadership style.</td>
</tr>
<tr>
<td>Non-verbal behaviour</td>
<td>Non-verbal behaviour is classified as active and passive non-verbal communication.</td>
</tr>
<tr>
<td></td>
<td>- Active non-verbal communication was apparent by means of kinesics, appearance and oculesics. Kinesics which originated from the Greek ‘kinein’ meaning ‘to move’. These were classified as regulators (e.g. nodding in USA vs Japan), adaptors (e.g. smiling, scratching), emblems (e.g. Khrushchev’s Victory sign, OK sign) and affect display (e.g. show of emotion). Appearance was defined as dress and adornment. Oculesics consisted of actions such as winking, eyebrow movement and eye contact.</td>
</tr>
<tr>
<td></td>
<td>- Passive non-verbal communication was classified as numerals, counting indicators, colour, olfactory communication and non-kinesics emblems.</td>
</tr>
</tbody>
</table>
Temporal conception may be defined as “the way in which individuals understand and use of time” (Victor, 1992, p.230). For example, a person considered biological time as an individual perception of their activities such as sleeping or working which were related to their health.

Table 2.2: The cultural models and their dimensions

Additionally, Hofstede (2001, p.212) remarked in relation to Hall (1959) that “High-context communication fits the collectivist society, and low-context communication is typical for individualist cultures”.

2.6 The importance and relevance of science and technology

Science significantly becomes embedded as an integral aspect with technology, and societies in many countries. This takes place through international exchange of knowledge, the internal developments of institutional connections, products and services and the movement of citizenships, for employment, or as tourism. Also science enhances science education through the demand and opportunities for ‘Science for All’ (Brock, 1996; Jenkins, 1999). “The Science for All slogan has a democratic ring about it that implies there’s something in it for everyone” (Fensham, 1986, p.19). The use of the term ‘Science for All’ from the perspective of Brock (1996), Fensham (1986), and Jenkins (1999) suggested science as an involvement of human activities with every part of everybody’s life. In addition, Said (2000) claimed that ‘Science for All’ was the new theme for preparing new generations in the twenty-first century. This theme might be useful for developed countries, including developing countries in order to contribute “towards making science a part of daily perception and understanding” (Said, 2000, p.31).

“It is difficult for students to perceive a relationship between the science problems they confront in everyday life and the science they study in school” (Burbules and Linn, 1991, p.228). The idea of Burbules and Linn (1991) demonstrated that science is an important part of peoples’ living, which
learning and understanding in science can be obtained from two major resources:

1) School science is a formal system.

2) Exploring science in everyday life is an informal system.

As Rennie (2007, p.131) asserted, “Over the last four decades, the educational role of museums has become increasingly explicit”. From this, the role for museums is to provide scientific knowledge which can be achieved by joining formal and informal system for people from different societies.

The relevance of science and technology is currently growing. UNESCO (2013, p.18) reported that “In a world increasingly shaped by science, technology and innovation, science education, including mathematics, is critical to the future employability of many young people”. Also the activities of science empowered in developing countries by UNESCO (2013) have promoted science education through 125,000 students in schools around the world as global programmes e.g. the International Year of Chemistry (IYC) and the Global Water Experiment. Furthermore, the governments of and the private companies in the countries of Germany, Switzerland, Sweden, Japan, and Korea have encouraged science and technology to contribute to the formation of important policies in the development of several crucial sectors e.g. agriculture, foods, and medicines, which were observed as successful (Brooks, 1994; Ergas, 1987).

2.7 Learning through interactive science exhibits

“Interactive and multimedia exhibits give visitors the ability to discover and learn at their own pace, plus, they engage individuals, keeping them interested as they experience the museum’s various themes on a tangible level” (Lewis, 2000, p.52).

Haywood and Cairns (2006, p.2) stated that, “Thus, museums must aim to provide entertainment that is simultaneously informative and educational. Increasingly, museums look to interactive exhibits to fulfil this aim”.

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Various comments from researchers e.g. Lewis (2000), and Haywood and Cairns (2006) demonstrate they have a common view that the provision of interactive exhibits should be a major duty required of museums – so that by means of these exhibits they may encourage and promote visitors’ learning.

Rennie (2007) started several main keys of the aspects which essentially correlated various issues of learning at the museums of science such as:

“Given that education is a recognized role of museums, do people learn from visit to museums?” (Rennie, 2007, p.132),

“Learning science from field trips” (Rennie, 2007, p.140),

“Research into Learning from Museum Visits” (Rennie, 2007, p.135),

“The role of docents” (Rennie, 2007, p.142) or the role of education staff.

The author set a framework of learning for museums including a new aspect: ‘Globalisation, tourism, immigration and virtual exhibits’. This was addressed by capturing and examining the discussions regarding learning interactive science exhibits in chosen museums of science following Rennie’s (2007) perspective methodology and other researchers’ methods described later.

2.7.1 The way visitors can learn through play

Dierking and Falk (1992) argued that if the visitors did not participate with all the materials in each exhibit - e.g. graphical information and objects - it showed precisely that visitors did not learn anything from the exhibits through their experiences. Piscitelli et al. (2003, p.11) believed that “Learning in museums happens when children connect with an interesting object or experience”. Faria and Chagas (2012) reported that 52 student visitors from different school grades (between 6-18 years old) learnt to play at science centres relating to their ages and exhibits. For instance, 30 students interacted with the temporary exhibits and “… they manipulated the exhibits without even reading the instructions and information in the modules (performing a ‘blind’ manipulation). They seemed ‘to play’ with the exhibits in an unstructured and unreflective way, whatever their age.” (Faria and
Chagas, 2012, p.591). On the contrary, 22 students in the permanent exhibits prior to using the exhibits studied the instructions, and after an interaction they reflected on their results, “... especially the older students, seemed very interested in interpreting the results of their manipulations because they used to read not only the instructions for manipulation but also the explanations offered in the exhibit” (Faria and Chagas, 2012, p.591).

Furthermore, visitors can learn at the museums in their own way such as “learning occurred continuously and was combined with an enjoyable experience” (Lelliott and Pendlebury, 2009, p.258). Similarly, Okan (2003) referred to use the term ‘edutainment’ materials that,

“All almost of the attention has focused on how to use them as a tool to increase students’ motivation and engagement in the learning context” (Okan, 2003, p.262).

Piscitelli et al. (2003) pointed out that young visitors frequently play with exhibits with enthusiasm and interest using their own ‘cognitive mapping experience’ rather than following learning patterns or protocols designed by museum designers. Also children always interact with exhibits slowdown to discover exhibits more selectively, objectively and quietly, after they engaged exhibits about half hour. The psychological term ‘cognitive map’ was first used by Tolman (1948) in which he defines it as a brain process of memory working with senses – e.g. seeing, smelling, touching, and hearing – as when animals and humans solve problems, they have to resolve these in their external environment. He cited that “learning consists not in stimulus-response connections but in the building up in the nervous system of sets which function like ‘cognitive maps’ ” (Tolman, 1948, p.194).

2.7.2 Out of school settings for learning science

Millar (2004) believed that many students were trained in school level as a ‘cognitive perspective’ to learn science which did not equip them to explore new ideas or engage in discovery.

Students must learn in schools because schools are part of the compulsory system of formal education. However, people could choose to learn in
various ‘settings’ or ‘institutions’ in which relevant learning could take place in an appropriate manner. For example, aquariums, zoos, national parks, botanical gardens, science centres and museums. The use of such alternative institutions for ‘free-choice learning’ should only be chosen when there is a compelling case for its use. For instance, the learners can fulfil their engagement for reasons such as supporting their curiosity of knowledge, motivation, enjoyment, and relaxation as informal learning system (Brody et al., 2002; Falk, 2005; Heimlich et al., 2004).

In terms of museums as a learning place in culture, Watson et al. (2002, p.126) stated that,

“By identifying factors in the museum environment that were contributing to student learning, suggestions could be made about the ways in which museum culture might be modified to maximise learning during school visits to informal museum setting”.

However, Vera et al. (2012) pointed out that the learning outside of school would incur costs and these may prove too great for some parents, possibly all parents. Examples of institutions where visits may involve cost are: museums, zoos, botanical gardens, and planetariums. Another factor to be taken into account is that these institutions may not offer bilingual information or multi-language translations, creating a problem for international visitors, as in the case of parents who take their family to visit such institutions.

There is also the difference between developed countries and developing countries. Falk (2005, p.266) remarked that,

“In the developed world, these infrastructures are rich and varied; in the less-developed world educational infrastructures are often impoverished and/or incomplete. Worldwide, most learning, and in particular most environmental learning, is acquired outside of school.”

Although the budgets for field-trips were a concern raised by Vera et al. (2012), nevertheless Falk’s (2005) aspects of learning science mentioned
‘learning outside of school’ as a necessary option both for developed countries and for developing countries.

2.7.3 The role of museum staff

Rennie (2007, p.142) explained the role of docents that,

“Docents, explainers, or education staff are available to assist school groups at many venues. Their roles may vary from leading structured tours to merely responding to questions, and teachers need to consider the role they wish docents to play during their visit”.

There are several kinds of job titles in museums such as chief executive, director, curator, curatorial assistant, conservator, educator, exhibition & display curator, exhibition designer, collections manager, visitor service supervisor, and visitor service assistant (Garlandini, 2011; Museums Association, 2014; Seaman, 2008). Herreman (2004, p.94) described the relationship of various museum staff working together to develop the exhibitions as,

“If there is an activity within a museum that is truly interdisciplinary, it is exhibition design. The designer, must work closely with the curator, the conservator, the administrator and the educator as well as with the electrician, carpenter, mason, and as many other specialists as are needed, according to the type of exhibition.”

In terms of the duty of staff to communicate to visitors by using several media, Dierking and Falk (1992) pointed out that graphical labels, artificial objects, and exhibits were prepared in considerable numbers by museum staff to stimulate and support visitors’ engagement. Seaman (2008) described the roles of volunteers and their view of what their duty to visitors were e.g. taking guided tours, communicating exhibits, evaluating visitor surveys, managing and attending visitors’ event and activities. Additionally, the role of museum staff may significantly focus on the school curriculum following the mission of its museum, for example,
“As an educational charity, the Science Centre in Cambridge will help establish the value of science, technology, engineering and mathematics (STEM) as vital skills for day-to-day life and future careers ... School groups are able to interact both directly on-site and through online forums with staff who are experienced in enhancing curriculum learning.” (Cambridge Science Centre, 2014, para.3). Such “...providing volunteers with skills and experience in hands-on engagement” (Dundee Science Centre, 2012, p.9).

2.7.4 Perspectives on Learning in science museums

Why do visitors visit science museums? There are many answers to this question. One example is using the learning models as the framework of perspectives on learning in museums of science as developed by several researchers such as Dierking and Falk (1992), Falk and Dierking (2000), Braund and Reiss (2004), and Falk and Storksdieck (2005). Dierking and Falk (1992) first presented the ‘interactive experience model’ in three contexts - e.g. the ‘personal context’, ‘physical context’ and ‘social context’. Falk and Dierking (2000) later modified this view by introducing more information relating to learning aspects of the ‘interactive experience model’ of Dierking and Falk (1992) and called it a ‘contextual model of learning in museums’ which comprised of three components - ‘personal’, ‘sociocultural’, and ‘physical’ contexts.

Falk and Storksdieck (2005) continuously used the same learning model from Falk and Dierking (2000) which they renamed as a ‘contextual model of learning to understand visitors learning from a science centre exhibitions’. Falk and Storksdieck (2005, p.745) claimed that, “The Contextual Model of Learning portrays this contextually driven dialogue as the process/product of the interactions between an individual’s (hypothetical) personal, sociocultural, and physical contexts over time”.

Bamberfer and Tal (2007) noted that the personal context involved several factors relating to individual persons such as prior knowledge, prior experiences, motivation, and interest in encouraging visitors to learn at science museums in their aspects of free-choice learning. Further, Falk and Storksdieck (2005) believed that the ‘Contextual Model of Learning’ could be
applied to evaluate visitors’ interactive experience in several informal learning institutions such as zoos, nature centres, science centres, planetariums, and natural history museums.

The three contexts and their associated 12 factors of Falk and Storksdieck (2005) formed the basis of the ‘contextual model of learning to understand visitors learning when using science centre exhibitions’. These are briefly described:


- **Sociocultural context** (6. Within group social mediation, 7. Mediation by others outside the immediate social group)

- **Physical context** (8. Advance organizers, 9. Orientation to the physical space, 10. Architecture and large-scale environment, 11. Design and exposure to exhibits and programs, 12. Subsequent reinforcing events and experiences outside the museum) - (Falk and Storksdieck, 2005, p.747).
The learning of Braund and Reiss (2004) in their ‘contextual model of learning in information, out-of-school contexts’ was developed from the Falk and Dierking’s (2000) model, ‘free-choice learning in museums’. However, Braund and Reiss’ (2004, p.115) three context models with 13 factors were strongly concerned with the cultural issues relating to interactions in the sociocultural context as ‘Norms and expectations of culture’ in figure 2.1.

![Diagram of Contextual Model](image-url)

**Figure 2.1: Contextual model of learning in information, out-of-school contexts**

[Retrieved image from: Braund and Reiss (2004, p.115)]
2.7.5 Globalisation, tourism, immigration, and virtual exhibits
In this new aspect to learning at the museums, the research question relating to learning through science exhibits was:

‘Do any people enter or access learning at the museums relating to other essential terms e.g. globalisation, immigration, and virtual exhibits?’ At present, the terms globalisation, immigration, and virtual exhibits might significantly influence people to become local, internal visitors, and online visitors as follows.

Precious (2010, p.3) stated that, “Another truth about culture is that it is dynamic. Culture is never static. Every now and then we are being transformed culturally”.

Obviously, culture is defined itself in its society based on social geography and also is not a ‘universal concept’. In terms of globalisation, people in different cultures and nations have ‘interaction and integration’ with each other into a conceptual idea of globalisation (Precious, 2010). For example the UK Association for Science and Discovery Centres (ASDC, 2014b) collaborates with the members of 60 major science institutions in the UK. “UK science and discovery centres, National museums, Science festivals, Learned societies, Environmental organisations, University departments, and Specialist outreach organisations” (ASDC, 2014b, para.5) have more than 20 million visitors per year.

These science engagement organisations support several ages and backgrounds of tourists around the world e.g. increasing science knowledge, offering ‘memorable learning experiences’, encouraging “trust and understanding between the public and the scientific community” and influencing the economic impact (ASDC, 2014a, para.2; ASDC, 2014b). In contrast to the benefits to tourism, the museums might always be concerned about the hygiene of their exhibits - as in the case of East Midlands Museums Service or EmmS (2002, p.31) which reported that
“The outbreak of Foot and Mouth Disease in 2001 has been a reminder of importance of tourism to the rural economy, and of the important part played by museums in providing a diverse and attractive rural product”.

In term of immigration, Hickman et al. (2008, p.65) claimed that “As in previous eras, the expanding demand for labour has been the primary driver of recent immigration to the UK”. Doudeijns and Dumont, (2003, p.13) reported that “In other host countries, i.e., Australia, Canada and New Zealand, permanent immigration is subject to a points system with an emphasis on the immigrant’s employability (age, education, skills, work experience) and the need for such qualified and experienced people in the country. These countries have therefore facilitated the temporary immigration of skilled labour in recent years”. Migration Advisory Committee (2010, p.2) argued that, “Some priority may also be required for limited migration into vital public services such as health, education and social care”. This migration might influence local British people’s attitudes to immigration which may be adversely affected e.g. social cohesion in everyday life such as education, cultural diversity, English language skills, accommodation, festivals, family, and work (Hickman et al., 2008).

Globalisation relates to virtual exhibits of several museums as reported in INDICATE (2012, p.37), for example, “Nowadays, the mutual exchange of global culture occurs in various ways and very often. One of the most efficient and effective ways of achieving audio-visual collaboration among people is by the use of computer networks, especially if long distances separate them”.

Further, INDICATE (2012) pointed out that virtual exhibits were considered to be important for museums’ visitors in several ways such as educational aspects, tourism and cultural industries through their website systems.

However, Eberbach and Crowley (2005, p.317) argued that “Interactive exhibits are increasingly popular, and one result is that replicated and virtual objects are often exhibited in museums alongside authentic objects”.

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For example, Eberbach and Crowley (2005) reported a study with 12 pairs (one parent and one child between ages 6-9) learning three types of flowers - e.g. living artificial, model, and virtual. The virtual flowers with virtual butterflies and artificial flowers might not enable students to understand all the features apparent in living flowers. The living flower enables students to more clearly understand the flower and to enter into the relationships of everyday experience - e.g. a child and the parent will talk to each other as they closely observe a living flower's pollination together.

2.8 The definition of interaction

“Interaction is a way of framing the relationship between people and objects designed for them - and thus a way of framing the activity of design. All man-made objects offer the possibility for interaction, and all design activities can be viewed as design for interaction” (Dubberly et al., 2009, p.69).

Allen (2004) suggested that visitors in science museums who could access interactive exhibits were an example of science learning and interactivity. Schneider and Cheslock (2003) commented that such interactivity and learning involved the visitors in understanding of engagement with and recall of exhibits in museums. In addition, the term 'physical interactivity' was observed as a principal characteristic of science museums and children museums which is “the ability of an exhibit to respond to visitors actions” (Allen, 2004, p.S24). McFarren (2001) pointed out that interactivity challenged visitors in the museums of science and involved them in collaboration with the technology by using their hands-on experience (physical interaction), and communication with other visitors (social interaction), and began with their personal experience (individual interaction).

Currently, HCI (Human Computer Interaction) has several classifications for interactions. For example, Dubberly et al. (2009) presented six types of interaction model which may apply to HCI or any interactive system – Two main basic components of systems are shown as figure 2.2. First, a linear system (closed-loop) where an input goes through a process becomes an output. Second, a self-regulating system which converts the linear system or open-loop into a closed loop system which the input has an effect upon the
process changed into a ‘compare’ which was emphasized by a ‘goal’, and the output modified to an ‘act’ relating to environments and disturbance).

These six types of interaction models were:

- ‘Reacting’ is a linear system of action which causes reaction and limited its function e.g. pushing the door and then it only opens.

Figure 2.2: Types of systems

[Retrieved these diagrams from Dubberly (2009, pp. 71-72)
• ‘Regulating’ is a linear system which related within a cycle loop as the ‘self-regulating system’ e.g. electrical power supports a heater.
• ‘Learning’ combines with two loops of the ‘self-regulating system’.
• ‘Balancing’ is the two loops, but the output becomes the input of another loop e.g. political and financial system.
• ‘Managing and Entertaining’ comprises three loops e.g. a learning system with entertainment.
• ‘Conversing’ is two loops of learning system or four loops of the ‘self-regulating system’ (Dubberly et al., 2009).

![Diagram of interaction models](image)

**Figure 2.3: Six types of interaction models**

[Retrieved these diagrams from Dubberly (2009, pp. 73-74)]

However, this research emphasises the understanding of types or classifications of interactive science and technology exhibits (ISTEs) with interactions' models. The latter are reviewed in the literature in the next section. Further, interaction analysis was used as a method for investigating the interaction of human behaviours in their activities process which connected the user to other people and relevant aspects of the environment. The effective tools of examination were video-based records of interactions, conversation, the usage of resources in artefacts and technologies, and nonverbal communication (Jordan and Henderson, 1995).
2.9 Interactive science and technology exhibits

The word ‘exhibit’ was not defined as having a single meaning, but the definition adopted in this research combined three different meanings such as “an exhibit unit (the display), an exhibit group (two or more displays on the same topic), and an exhibit area (a collection of displays with a similar, general theme)” (Bitgood, 1992, p.4). Serrell (1996) broadly defined an exhibit as ‘discrete, conceptual units, and experiences’ including the exhibit components which were developed by designers in various sizes and formats. For instance, “a panel, a case, a diorama, a set of artifacts, a video theater, a computer, an interactive device” (Serrell, 1996, p.238).

Bitgood (1991, p.4) defined “an ‘interactive exhibit’ as a device in which the visitor’s response to the exhibit produces a change in the exhibit”. However, this definition of interactive exhibit did not include ‘mental interaction’, but it specified only ‘physical interaction’ such as a simple way to turn the light on-off or a complex way to interact with a computer (Bitgood, 1991). “At an interactive exhibition, visitors can act on the exhibit and the exhibit reacts back on them” (Rhee and Kim, 2013, p.2).

The types of exhibit which involved visitors in responding to their engagements are: simple hands-on, participatory, and interactive exhibit. ‘Simple hands-on’ exhibits involved the visitors in responding by taking actions e.g. climbing on an artificial animal or touching fur (Bitgood, 1991). ‘Participatory’ exhibits encouraged visitors to interact with the exhibit rather than making one response. These ‘Participatory’ exhibits, however, compare the standard objects and the visitors’ interaction e.g. feeling of hotness, smoothness of many materials (Bitgood, 1991; McLean, 1993). McLean (1993) points out that interactive exhibits present visitors within options from which they must choose one or more options e.g. doing activities, evaluating skills, and choosing options.

On the contrary, hands-off exhibits are not interactive and they are defined as “Traditional forms of museum displays are either passive (glass showcases) or active (working models of machines)” (Ramsay, 1999, p.29).
At present, interactive science exhibits are located in both science museums and science centres identified by Friedman (2000) and Galluzzi (2000). Additionally, Friedman (2000, p.43) remarked that “Science and technology centres are a relatively recent subset of the science museum realm, with a specialization on ‘hands-on’ or ‘interactive’ exhibits, and a spectacular record of growth”. For science centres, Galluzzi (2000) pointed out that the evolution of interactive engagement has been situated significantly in the science centres. However, the early science museums attempted to develop many interactive exhibits in conjunction with their old collections. It might be significantly concluded from Bitgood (1991), McLean (1993), Friedman (2000), Galluzzi (2000), and Rhee and Kim (2013) that the term ‘interactive science exhibit’ were interactive exhibits which had science knowledge embedded in them and located in museums of science.

Furthermore, inclusive design of science exhibit has begun to be addressed; Tokar (2004) reported the results of a survey of ‘Universal Design’ (UD) practice among North American museums with hands-on science exhibits, which explored their advantages and disadvantages. Tokar (2004, p.9) suggested that ‘access for all’ or ‘of value to every visitor’ of science exhibits might include provision for use by people with disabilities e.g. mobility impaired visitors using a wheelchair, blind/low-vision visitors, and deaf/hearing impaired visitors. So far, the author believes that the design of interactive science exhibits in term 'Universal Design’ does not appear to have taken into account that of cultural differences.

Currently, many science museums, science centres, and learning science centres accommodate technology with interactive science exhibits. For instance, the Eugenides Foundation (2007, para.1) pointed out that “The Interactive Exhibition on Science and Technology seeks to bring the general public closer to the world of science and technology, a world which might seem mysterious and remote to most people. The Exhibition highlights current scientific and technological achievements and explains basic aspects of various phenomena. New composite materials, technologically advanced
devices, simulations, models and specially designed activities are at visitors’ disposal for exploration, experimentation, entertainment and learning”.

The definition of ‘Interactive Science and Technology Exhibit (ISTE)’ is defined in this thesis from several previous references as a device which is designed to support visitors to learn any science topic in museums by using visitors’ interaction and feedback responses to the visitors. For example, a visitor speaks to a disc and the visitor can hear the sound from the second disc of another speaking visitor. This device may be a technological component such as a touch screen monitor, a computer, a digital camera, a microphone, and a speaker (Bigood, 1991; McLean 1993; Friedman 2000; Galluzzi, 2000; Tokar; 2004; Eugenides Foundation, 2007; Rhee and Kim, 2013).

2.10 The classifications of interactive science exhibits

At present, the term ‘interactive science exhibit' is generally found rather than ‘interactive science and technology exhibit'. For example, several classifications of ‘interactive science exhibits’ were developed by many researchers such as Ghose (2000), Gilbert and Stocklmayer (2001), Sandifer (2003) and Afonso and Gilbert (2007). A case in point is Boisvert and Slez’s (1995) classification, where the term ‘interactive exhibit’ was always used instead of ‘interactive science exhibit’. Developing guidelines for the inclusive design of interactive science exhibits requires classification of the types of interaction which they provide to the user. Such classification should eventually enable greater analysis of the educational purposes and effectiveness of different kinds of interaction. The summarised classifications in the following table are examples which are taken from the original references.

<table>
<thead>
<tr>
<th>Authors</th>
<th>interactive science exhibit classifications</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boisvert and Slez (1995)</td>
<td>1. Low interaction, concrete, simple</td>
<td>“…style 1 exhibit was designed as ‘museum showstoppers’ … Their main function is to attract visitors into the exhibit area” (Boisvert and Slez, 1995,</td>
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<td>2. High interaction, concrete, simple</td>
<td>The style 2 exhibit is small and provides hands-on activities. “…highly interactive style 2 exhibits had lower attracting power than style 1 exhibits but had much higher holding power” (Boisvert and Slez, 1995, p. 515). He pointed out that style 2 exhibits created more interaction than style 1 because of their superior holding power.</td>
<td></td>
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<tr>
<td>3. High interaction, concrete, complex</td>
<td>The style 3 exhibit “scored highest on attraction, holding power and visitor engagement” (Boisvert and Slez, 1995, p. 515). For example, a pig’s heart or real artefacts or fine replica.</td>
<td></td>
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<tr>
<td>4. High interaction, abstract, complex</td>
<td>The style 4 exhibit offers a wide range of highly interactive participation on particular subjects such as discovery boxes.</td>
<td></td>
</tr>
<tr>
<td>5. Low interaction, abstract, complex</td>
<td>The style 5 exhibit gave complex information such as a video library, books, and the visitor had interaction with none three-dimensional objects.</td>
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<table>
<thead>
<tr>
<th>Ghose (2000)</th>
<th>Hands-on exhibits are operated by visitors in different ways such as visitors interacting by means of questions generated by the exhibit.</th>
</tr>
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<tbody>
<tr>
<td>1. Two-way communication</td>
<td>Hands-on exhibits where the visitors attempt to experiment in various ways to operate the exhibit.</td>
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<tr>
<td>2. Multiplicity or multiple operation</td>
<td>Minds-on exhibits where visitors can discover by themselves.</td>
</tr>
<tr>
<td>3. Discovery process</td>
<td>Minds-on exhibits where visitors can cross time and space in a simulated situation. In addition, Ghose (2000) commented that “This is done by faithfully recreating a walk-through period setting with artifacts of the time.</td>
</tr>
<tr>
<td>4. Simulated situation</td>
<td></td>
</tr>
<tr>
<td>Reference</td>
<td>Description</td>
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</tr>
<tr>
<td>Ghose (2000) [continued]</td>
<td>and sometimes animated with sound and light effects” (Ghose, 2000, p.124-125). Examples of minds-on exhibits are a space flight, a time machine through the creation of the solar system or the Jurassic habitat and the micro-world of atoms.</td>
</tr>
<tr>
<td>Gilbert and Stocklmayer (2001)</td>
<td>1. A simple demonstration of a phenomenon</td>
</tr>
<tr>
<td></td>
<td>2. Matching both a real-world phenomenon and the consensus model</td>
</tr>
<tr>
<td></td>
<td>3. A ‘far’ analogy to represent the consensus model</td>
</tr>
<tr>
<td>Source</td>
<td>Criteria</td>
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</table>
| Sandifer (2003)                | 1. Technologically novel: It will meet “…at least one of the following criteria:  
2. Open-ended: It will meet “…at least one of the following criteria:  
3. User-centred: It will meet ‘…if the outcome of the exhibit manipulation involved a representation of or an effect on the user’s body or voice’ (Sandifer, 2003, p.128).  
4. Stimulates the senses: It will meet “…at least one of the following criteria:  
   1. The exhibit emitted sounds on its own or when in use.  
   2. The exhibit had one or more visible parts, objects, or images that moved on their own or when the exhibit was in use.  
   3. The exhibit had lights that blinked or flashed on their own or when the exhibit was in use” (Sandifer, 2003, p.128). |
| Afonso and Gilbert (2007)      | 1. Exhibits as exemplars of phenomena: An ‘exemplar of a phenomenon’ is an idealized exhibit of a real-world phenomenon. It connects the experience to the phenomenon directly. For example, ‘Silent bell’ which
Afonso and Gilbert (2007) [continued]
presents the sound of a bell inside the vacuum jar which is a sound of greatly reduced intensity and clarity (Afonso and Gilbert, 2007).

2. Analogy-based exhibits

An ‘analogy-based exhibit’ defined as an analogical representation of a consensual scientifically accepted model of a phenomenon. For example, the exhibit of bat which is a model emits a sound which simulates the sound of a bat (by reducing the frequency of the sound until it is within the frequency of sound perceived by the human hearing. The visitors can hear the sound of bat model by pressing a button (Afonso and Gilbert, 2007).

Table 2.3: A summary of methods for classifying interactive exhibits

2.11 The existing design guidelines for interactive science exhibits

Design guidelines were used as a construction to develop an interactive science exhibit by exhibit designers and educational staff at their museums of science (Bitgood, 1994; Abeyaseker and Matthews, 2007). However, the term ‘guideline’ will be “used to indicate voluntary compliance and self-monitoring” (DiGiacomo, 2002, p.1). Several existing design guidelines of interactive exhibits emphasise various aspects of these designs e.g. education, entertainment, and sustainability as follows.

At the Exploratorium (in the USA), Bruman (1984) and Hipschman (1980; 1987) recommended the exhibit design checklist for the overall design of interactive science exhibits relating to visitors’ interactions. For example, large font sizes on the graphic panels were recommended for people with visual problems. Speakers should be located to produce sound in front of visitors. They provided for the special needs of key group of users e.g. easy usage for children, accessibility for disabled persons with walking support devices and wheel-chairs. Additionally, Lin (2009) recommended the checklist in the design and development of museum exhibitions as a
reminder to make sure certain functions provided in the appropriate features. This is a similar idea to the checklist in the Exploratorium (Bruman, 1984; Hipschman, 1980; 1987). The interactive exhibits should be designed to have concise and simply graphical guidance to minimise the time to read through message contents, provide suitable visual features for the interactions, and follow ergonomic theories (Bitgood, 1994). At the Smithsonian Institution, Pekarik et al. (2002) reported that an interactive exhibit should be developed to generate interest, minimise confusion, stimulate imagination, accommodate multiple users, and provide entertainment. These recommendations will help to develop its proper design. Also “Texts and other communication media should be accurate, honest, and clear, yet allow and present differing points of view” (DiGiacomo, 2002, p.9).

The visitors could access the ‘interactivity’ of exhibits through their actions e.g. causing something to appear on a screen, providing a reward in similar or disimilar outcomes, and providing a personalised review of the results of their interaction (Sciencenter, 2004). Abeyaseker and Matthews (2007) developed guidelines for designers of small scale interactive and travelling exhibits which were concerned with environmental issues, global warming, energy usage, reduced pollution and their heavy weights in transportation.

At the Museum of Science in Boston, NISE Network (2010, p.4) suggested that hands-on exhibits should offer a universal design in terms “…, as opposed to ‘separate but equal’ accommodations for persons with disabilities”, including for various ages, abilities, cultures, and learning styles.

At Thinktank - Birmingham Science Museum, Kirby et al. (2011, p.5) described the considerations in the exhibition design and construction guidelines that “The exhibitions need to be safe, be attractive, inviting and engaging, be accessible as many as possible (ergonomic, cultural, social, intellectual, conform to relevant standards and legislation, be of high quality in design, manufacture, and materials, be of ‘green’ design, using reused, recycled materials …”.

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However, Macdonald (2007) believed that many museums have frequently carried out research observing visitors in their own organisations where the exhibit designers might improve a few aspects of the designs to promote better visitors’ interaction. “The fact that these are generally institutionally disconnected from designers also means that there is often insufficient attention to the matters that could really influence design…” (Macdonald, 2007, p.159). The implication of this statement of Macdonald (2007) is that design is fundamental and is seriously disconnected to other museums. Without knowledgeable designers in the design process many potentially innovative and attractive designs will not be considered. This, with the lack of addressing cultural factors in design makes a strong case for the generation of new guidelines. The new exhibit guidelines embody much of the design knowledge and cultural factors which can be used by the museum staff.

2.12 Culture and science education

Millar and Osborne (1998, p.4) stated that “Science has transformed not only our material environment but also the way we think of ourselves, of the universe we inhabit, and of our place within it. The ‘stories’ which science tells about the material world and how it behaves have made an enormous contribution to our culture”. This statement shows the very important relationship between science and culture, and particularly that neither can be understood nor utilised in any society without knowledge of science and culture.

At present the cultural globalisation needs to be comprehended as the processes of the combination for many people to attend (Ang, 2003). Ang (2003) agreed with other researchers who have the same idea as him about the understanding of the cultural globalisation such as Néstor García Canclini (García Canclini, 1995 and 2000) and Ulf Hannerz (Hannerz, 1996). “Culture is ingrained in the community and transferred to new generations. People should appreciate and celebrate science as a cultural product” (Millar, 1996, p.9). Millar (1996) suggested that science is part of culture which needs to communicate to other people in society. Bazin et al. (2002) believed that in the history of humankind, people attempted to understand nature and applied
nature to improve their life. Human had created science and technology by knowledge in their cultures which have derived from nature. In addition, “Today the products of scientific discovery (including the mass media) represent the major force of culture change, and for most countries in the world they arrive mainly or exclusively from outside” (Hofstede, 2001, p.34). On the other hand, Hofstede (2001) pointed out that culture change can be altered in many countries by applied science in their social life as part of their culture.

2.13 The 10 dimensions of cultural issues relating to interactions

Brislin (1993) asserted that the investigation of human behaviour was meaningfully supported by taking into account relevant cultures and the differences between the varying cultures across the world. The outcomes of investigations into these differences might not be successful where the common meaning of culture in concepts, values and beliefs is used. So the consideration of culture and cultural differences needs to take into account expected behaviours in the various cultures. Brislin (1993) concluded that human interaction is based on human behaviour and people’s cultural background. Also Marcus (2006, p.62) claimed that “Today, anthropologists, ethnographers, usability analysts, and designers of all persuasions contribute to the lively ‘Anthropologists in Design’ discussions that cross all platforms, vertical markets, development theories, and professional practice.” He concluded that any product design needed to take fully into account cross-cultural issues as the most important and potent trends in product or service reinforcement.

The 10 cultural dimensions relating to interaction designs were identified from the literature reviews as follows.

- **Physical skills**

Physical means relating to the body rather than the emotions or the mind and connecting to things that can be felt, heard or seen (Cambridge Dictionaries Online, 2012d; Longman English Dictionary Online, 2011; Oxford Advanced Learner’s Dictionary, 2013c). In terms of aspects of psychosocial development, physical skills/motor skills – these were defined as “Improve
coordination, balance, agility through large muscle activity” (UNICEF, 2014, p.8). Skills such as information management, intellectual capacity, social communication, and physical skills have been achieved to access general learning outcomes of any interactive exhibits and any interactive technology devices by the visitors at museums (Danks et al., 2007). Interactive exhibits have been designed to be operated by physical skills of manipulation in order to encourage visitors’ learning (Caulton, 1998). Ecsite (2008) referred to a term ‘skills’ e.g. social skills, communication skills, intellectual skills, and physical skills which visitors could gain as benefits of the learning outcomes at museums from a report of the Museums, Libraries and Archives Council or MLA (2008). For example, physical skills are “running, dancing, manipulation, making…” (Ecsite, 2008, p.12). Also, “Hands-on manipulation and playful experimentation with museum exhibits allow children to use their senses and bodies as tools for learning” (Piscitelli et al., 2003, p.23).

Furthermore, the definition of ‘manual’ defined in this thesis, and synthesised from the quoted references - was ‘operated by hands or using physical force rather than using the mind and done without the assistance of motors, computers, electricity, and electronics’ (Cambridge Dictionaries Online, 2012c; Longman dictionary of contemporary English, 2003d). Mark (1996) explained that there are two kinds of automation – fully automatic and part manual operation. He gave an example of an automatic system - a thermostat which may stop working in winter when triggered by cold temperatures. It can also be operated manually by turning it off.

Allen (2004) noticed that the use of interactive exhibits by visitors should be analysed carefully. Take turning a knob clockwise to increase magnitude as a cultural standard - exhibits should be “using natural mappings to take advantage of physical analogies and cultural standards” (Allen, 2004, p.21). Similarly, some exhibits appeared as inadequate from the design of their physical options, lack of qualitative directions, and uncommon cultural design e.g. reducing a variable by rotating a knob clockwise (Allen and Gutwill, 2004). Many museums have used the technology of interactive media in what are called kiosks which could be related to physical skills. These kiosks are
placed within the museums’ educational public programmes and museum collections. Kiosks also have easy-to-learn interfaces which the visitors can interact with using the ‘press a button’ (Edwards and Lees, 1974; Bainbridge, 1983; Roussou and Efraimoglou, 1999). Furthermore, Rasmussen and Vicente (1989) pointed out that skill-based levels were necessary to develop the operations and the features on interface surfaces. Interfaces must follow the elementary movements into higher levels of manual skills and are more complex than routine interactions such as controlling a mouse or a tracker ball. The performance of manual skills was measured commonly in the correlation of both hands asymmetry (Singh et al., 2001). Bainbridge (1983) pointed out that there are differences between the operators who are experienced and inexperienced in relation to manual control skills. A small number of actions are made by experienced users and progress is smooth and rapid to the next steps of the process. On the contrary, inexperienced users control hunting around the process getting to the end by an indirect route.

Additionally, left and right-handedness is one of the major differences between natural physical movement for the two groups and this needs to be taken into account. McManus (2003) gave examples of different cultures having different attitudes to left-handedness in their societies. For instance, “Far milder is the situation in the Central Celebs (Sulawesi), where the Taradja accepted that left-handers were amongst them but merely said they were stupid” (McManus, 2003, p.295).

On the contrary, “… a Japanese proverb that a left-handed child may grow up to be a genius because of being different” (McManus, 2003, p.296). Further, McManus (2003) reported that several types of left-handed devices and products were selling on websites - e.g. in the UK, the USA, and Australia – and these could prove very convenient in the life activities of many left-handed people - e.g. watches and clocks, micrometers, rulers, belt tape measures, boomerangs, army knives, digital cameras, garden equipment, golf equipment, left-handed chords for guitar charts, guitars, banjos, peelers, corkscrews, can-openers, pencil sharpeners, and scissors.
Technologies issues

Technology is defined as “… ‘applied science’. Historically and methodologically, it can be shown that technological progression can only partially be accounted for by the use of scientific knowledge” (Vries and Tamir, 1997, p.5). Furthermore, Hughes (2005, p.4) pointed out that “In 1959 the Society for the History of Technology began publication of a quarterly journal entitled Technology and Culture. The bewildering variety of things and systems referred to as technology in the journal's first two decades reveals technology's complex character. Rockets, steam and internal combustion engines, machine tools, textiles, computers, telegraphs, telephones, paper, telemetry, photography, radio, metals, weapons, chemicals, land transport, production system, agricultural machines, water transport, tools, and instruments all appear as technology in the journal's pages.”

Norman (2000) suggested that the knowledge of essential technologies can be promoted and disseminated through leading design with mechanics, electronics, and thermodynamics. Teaching can be promoted by ‘showing’, learning by ‘doing’ and these are demonstrated and illustrated in appropriate design and technology curricula. Also skills training is necessary to provide people with the capacities they need to convey the technology concepts, facts, and figures through ‘experience’.

Sato and Chen (2008) commented that mobile phones, the internet and networks were new technologies which impacted on and changed the lifestyle of people. These artefacts influence people’s interactions and create a new culture base for their social and environments. “Emerging technologies such as smart phones and tablet computers are now further changing the way technologies are used in cultural spaces. In addition, the use of technology in cultural spaces is now not limited to audio commentary, but may provide diverse content types such as images, video and multimedia” (Othman et al., 2011, p.93). Othman et al. (2011) view was that museums where currently technology was used as a part of its mission to promote
human culture could be termed ‘cultural spaces’, defining the latter as “Museums and other cultural institutions such as art galleries, historic houses, and archeological sites” (Othman et al., 2011, p.92).

There is a close relationship between culture, interaction design and technologies issues. This was very apparent in the interview by Chittaro (2008) with John Thomas who worked in the field of human-computer interaction with IBM for 30 years. Examples of the interview questions were: “Can interaction design be afforded by the richest countries only? What role is it playing or should it be playing in developing countries?” Chittaro (2008, para.2) and John Thomas replied that “…interaction design deals with the fundamental match between human needs and values on the one hand and what is possible technologically on the other. Without an adequate understanding of the communities, cultures, and practices in developing countries, the limited resources of developing countries will be wasted” (Chittaro, 2008, para.4). On the other hand, Sieffert (2006) claimed that the cultural issues were key factors in the design materials as well as the culturally sensitive materials. The usage of technology also interacted with culture. The designers were affected by their culture as learners were through many generations.

Moreover, Hornecker and Buur (2006) believed that traditional object exhibits emerged with hybrid and digital equipment - such as an abacus exhibit. This exhibit had tangible beads like a traditional abacus, and this was placed in front of a computer screen which gave visitors directions on how to use it and took them through a learning protocol. Wyeld et al. (2006) reported on a 3D virtual environment (3DVE) which was studied in a cross-cultural exchange as a 3D virtual cultural environment (3DCVE). The three cooperating institutions were in different countries namely Australia, Taiwan and Norway. The students collaborated with their tutors and other students to do the activities of role-play such as social events and various discussions. The tools of 3D co-located laboratory (3DCollab) were chosen for use with video conferencing, chat, 3D virtual worlds and email. The use of 3DCollab aimed
to support inter-cultural collaboration in this 3DCVE and other educational contexts.

In the literature review of culture and interaction design, technologies issues were found in two main areas - Human Computer Interaction (HCI) and User-centred design (UCD) - as follows.

**Human Computer Interaction (HCI)**

“An oversimplified definition of HCI might say that it is the study of the interaction between humans and computer” (Booth, 1989, p.4). He noted that ‘HCI’ is the most commonly used term to refer to the subject area in the academic community rather than ‘Computer and Human Interaction’ (CHI), ‘Human-Machine Interaction’ (HMI) and ‘Man-Machine Interaction’ (MMI). Harper et al. (2008) suggested that the rapid changes in computer, technology, people and society affects our aims, ambitions, and aspirations. Peoples’ concerns may relate to out dated notions of ‘computer’, ‘user’ and ‘interaction’ in HCI. This makes the case for HCI research in up to date applications with particular emphasis on outcomes. Pereira et al. (2011) reported on his investigation into the use of ‘Valuation Framing for Social Software’ (VF4SS). The VF4SS was used to evaluate the interaction design of social software in terms of HCI paradigms. The software could analyse the cultural dimensions of a product. The 10 areas of Primary Message Systems (PMS) which related to the basic building blocks of culture were: association; classification; defence; exploitation; interaction; learning, play; subsistence; temporality and territoriality.

Markuseen and Krogh (2008) implied that the embodied interaction and cultural meaning construction were analysed by HCI as part of a larger interactive system. DiPaola and Akai (2006) pointed out that many traditional technology exhibits did not provide interaction for groups of visitors e.g. only one person was able to operate a computer with a mouse. The new insights of the design should provide to the visitors. The design should promote a good user experience and significantly increase visitors’ scientific understanding. The museums, aquaria and science centres could create such an experience by using techniques involving multimedia interactivity.
For example, the visitors could watch the media together on the large plasma screen display under the full control of the experienced staff (DiPaola and Akai, 2006). Additionally, the particular interest of HCI on the website was concerned with virtual environments. For instance, McLoughlin and Oliver (2000) stated that a learning community online should be developed incorporating various styles of learning. The designers should take into account the cultural issues affecting online learning environments for indigenous social learners.

For gesture display technology of human computer interaction, Rehm et al. (2008) remarked that understanding cultural interactions could be investigated by a gesture recognition device relating user’s behaviour to their different cultural backgrounds. This device can be used for information presentation, game entertainment and educational game. For example, “…Wii remote controller (Wiimote) to capture the user’s gestural behavior. The Wiimote uses accelerometers to sense its movements in 3D space” (Rehm et al., 2008, p.17). The theory of conceptual blending was created by Fauconnier and Turner (1998; 2002); the theory considered the everyday life of people and how people created meaning by their acting, talking and thinking. The use of the theory led to the idea of user experience as an imaginative element in the interaction design. In addition, web page creation could be used to distribute knowledge to people. For example, Buzatto et al. (2009) suggested that the ‘Cog-Learn Pattern’ software helped teachers to create e-learning content. The software has been developed using HCI theories. The ‘e-Learning Pattern Language’ can also support pedagogical issues such as culture sensitivity.

User-Centred Design (UCD)

Gulliksen et al. (1999, p.6) stated that “… a user is a person who will use the system for performing tasks that are part of his/her job or leisure activities. People, who are only circumstantially affected by the system, are considered stakeholders, e.g. managers or support personnel.”
In addition, Gulliksen et al. (2003) defined user-centred system design (UCSD) as a process where the aim was to complete the development process for a specified group of users to attain particular task goals with effectiveness, efficiency and satisfaction in the system life cycle.

Segerståhl and Jokela (2006) stated that an influential method for connecting the space between analysis and design in user-centred design is interaction patterns. There were no universally accepted standard documents of interaction patterns in use. The expressive formats were presented in an abstract form and were difficult to characterise clearly. The usability of the interaction patterns’ methodology needed to be improved such as:

- Problem based grouping such as groups named, e.g. navigation, searching
- Use of graphics and examples with the role and variety of references
- Naming
- Integrating Pattern Collections

Jokela et al. (2003) reported that ISO 9241-11 and ISO 13407 were the two important standard systems relating to usability in design. The guidance for user-centred design defined usability as effectiveness, efficiency, satisfaction, context of use. Goal and task were identified in ISO 9241-11. Guidance on the activities required throughout the life cycle of computer-based interactive systems was provided by ISO 13407 which identified four different aspects such as rationale, planning, principles and activities of human-centred design.

In the literature review, User-Centred Design (UCD) was presently found in two main groups - User Interface Design (UI) and Cultural User Interfaces (CUI) - as follows.

- **User Interface Design (UI)**
  Hornecker and Buur (2006) stated that tangible interaction design and tangible user interfaces (TUIs) had important aspects of HCI. In the last two decades, new types of interactions had been generated: digitally-augmented physical spaces, graspable user interfaces, physical-digital interactions,
tangible interaction or tangible user interface. These interactions involved the full-body and tangible interaction which related to a large space design. The design needed to provide as ‘real world’ experience of interaction as possible of user experience in an everyday social environment, such as face-to-face social interaction. For an example of an inappropriate website, take FedEx. This is a transportation company for carrying any legal goods of its customers to other countries in the world. Its website advertised sending parcels to Saudi Arabia and had an Asian lady’s face with bare arms in the image. This would probably not be suitable for Saudi Arabia. It also linked to a comparison of many interactive exhibit designs which provided such information and similar requirement for varying countries to inform proper user-interface designs (Marcus, 2006).

McFarlane and Latorella (2002) explained that multitasking systems offer an interaction between computers and users such as conferencing with other users, writing a report and calculating a financial plan. However, these various interactions disturbed the other activities of users who were still doing a prior task. Further assistance might also become a crucial operation that obstructs the user. The vital success or failure of the human-computer interaction was the user interface (UI) which must be supported by existing design guidance relating to multitasking situations.

In addition, an ecological interface design (EID) was developed for supporting three levels of cognitive control such as knowledge-based, rule-based and skill based. An optimal interface design was proposed as a guideline for learning processes which could reduce errors in the human-system interaction (Rasmussen and Vicente, 1989).

Dillon (1998) believed that the relationship between resulting-interface use and cultural analysis could be identified by the influence of an ethnographic analysis. The designers might learn the process of ethnographic analysis at the early stages of user and task analysis. Ethnographers were not trained to work with the system designers. Hence, the designers might learn the cultural analysis from their experience in the design association.
The designers should understand the users so as to be able to explore alternative design. For example, young and old designers who have different experiences can work together to represent the software in its cultural context. The video for developing real observations can be useful for user centred design (Gulliksen et al., 1999).

- **Cultural User Interfaces (CUI)**
  Oh et al. (2011) pointed out that the CUI generator could be adapted to many devices such as mobile phones, websites, etc. It can generate friendly user interfaces. The basic idea for using CUI is to compare and discuss cultural factors (it comprised a cultural dimensions model which showed the dissimilar characteristics with cultural area and cultural markers which were cultural symbols), cultural user interface and user’s cultural background. It also relates to user experience in terms of accessible, credible, desirable, findable, useful, usable and valuable. For example, the pictures of a timeline were presented from top to bottom as vertically in China and Japan. The present timeline is at eye-level and the future appears at chest-level (Schaefer, 2011).

Kirigin (2005) reported that Usability Professionals’ Association (UPA)’s website thought that non-Western people might not have confidence in the enquiry from the website and not be willing to pay or register online. The system needed to create strong confidence in this enquiry in these people. As a consequence, the influence of their cultures undermined their use of the new systems.

Clemmensen (2010) gave an example of how the design of technology interacts with cultural differences. The example was word processing technology as it affects many countries in the world such as Japan, Denmark and India. The style and protocols of word processing influence other devices such as computer keyboards and smart phone text editors. This evidence demonstrates that human computer interaction and culture are interconnected in usability issues. The development of science and technology may be influenced by global cultures.
Celentano and Pittarello (2001) believed that the new content-centred methodology was designed for production of 3D interactive environments. The methodology had been developed to generate guided tours for the events in cultural heritage. For example, the cultural applications focused on the final user interacting by doing the tasks and understanding the user experience through user centred design. The life cycle of 3D interaction design comprised meta-author, interface designer, final user, author, editor, 3D modeller and world builder.

However, Human Factors International (2012) concluded that one definition and model of culture in interfaces and product design would not produce usable interfaces and products for all countries. The dimensions of cultural diversity were said to be massive. The understanding and knowledge of local cultures were researched by local experts who conducted experimental work in their countries such as Brazil, Chile, Guatemala and Saudi Arabia. The three main phrases have been identified in the procedure to make a software system or product highly usable e.g. evaluate cross-cultural interfaces or products by local expert reviews, design for multi-country usability and examine these interface and products in new cultural contexts.

- **Language issues**

Crystal (1987, p.424) defined ‘language’ as “The systematic, conventional use of sounds, signs, or written symbols in a human society for communication and self-expression.”

Trager (1949, p.5) considered the definition of language relating to cultures. He remarked that “A language is a system of arbitrary vocal symbols by means of which the members of a society interact in terms of their total culture”.

Additionally, Holtgraves and Kashima (2008, p.89) believed that language and culture are strongly related and influence each other: “Although we view the relationship between language and culture as being reciprocal, the nature of this relationship changes as a function of the time
frame with which it is viewed. That is, a certain way of culturally based thinking can play a role in the development of language.”

Hofstede (2001) reported that the IBM Company surveyed the 40-71 countries in 1971-1974 with the questionnaire and the languages used. The original versions of the international questionnaires were created in English. It was discovered that some words such as ‘achievement’ were rarely able to be translated to other languages.

In term of offering information in optional languages for international visitors, Lewis (2000, p.52) recommended that “Such guides usually provide information in multiple languages and can even display directions to specific areas of the museum”.

Further, Grammenos et al. (2011) cited that typical multimedia information kiosks of the interactive exhibits provided the visitors with the selection of choices, so visitors could create their own educational experiences e.g. the visitors selected their own language, they could control the simple electronic interactions such as playfulness by reading manual instructions and learning from other visitors. They could also take photos of their own in funny poses.

For example, a particular language which was part of culture affected an understanding of people who have cultural differences such as in the case of dates and numbers. Where the Spanish language is concerned the Spanish user frequently applied using online conference submission forms by filling in their Spanish names. However, the online forms were not designed to support international characters, and the submission could not be accepted. This problem with language issues often affected various areas of computer operation (Keller et al., 2006).

Schaefer (2011) pointed out that Chinese, Japanese and Korean languages can be typed and written as text in a formal content from top to bottom. English was written from left to right. Hebrew language starts writing from right to left. Japanese comic books were printed and read from back to front.
“The basic assumption in the concept of a pattern language is that patterns are related to each other, forming a network of connected patterns” (Van Welie and Van der Veer, 2003, p.528).

Additionally, Van Welie and Van der Veer (2003) remarked that connecting patterns could link to other patterns of interaction design within three types of pattern languages which may apply in the web designs such as aggregation (performing lists in the group functions or called as ‘has-a’ relationship e.g. ‘delete’, ‘change quantity’, ‘view’), specializations (extending options or called as ‘is-a’ relationship e.g. simple search into advance search which made a special feature on another pattern), and association (relating other patterns or called as ‘related-to’ relationship e.g. a feature of ‘product comparison’).

- **Visual cultures**

  Visual culture as defined by cultural influence of the image, is the relationship between culture and vision, rather than concepts and experience (Düttmann, 2002; Keifer-Boyd et al., 2003). In terms of visual cultures as a sign, Marcus (2006) noted various types of cultural characteristics such as artefacts, leaders/supporters, small-scale and large-scale behaviours, signs, and values. Designers who were analysts might be conscious of culture as cultural bias and in these situations culture will influence the design of signs, objects and equipment (Marcus, 2006). The examples of signs relating to visual culture are: Firstly an example of visual cultures in a particular culture, - people living in North East Angola (South Western Africa) who were called the Chokwe (pronounced ‘chockway’) using their art to tell a story. “They have an ancient tradition of making sand drawings, known in their language as lusona (plural: sona), to illustrate their stories. The sona illustrate proverbs, fables, games, riddles, and stories about animals” (Bazin et al., 2002, p.4).

  The second example is from a sand trail exhibit, or more commonly known as fading motion exhibit. Allen and Gutwill (2004) reported that with the first version of the sand trail most visitors tended to control a large dial of damping mechanism more than a small knob of belt control on the right-hand side. Hence, Allen and Gutwill (2004) recommended the need to fix this
trouble by removing the damping control and building a belt drive control to be more noticeable. The visual cultures also impact on the meanings of colours which vary in different cultures - e.g. Weinschenk (2011, p.27) described that “Colors have associations and meanings ... If you are designing for people in different parts of the world, then you have to also consider the color meanings in other cultures.”

For instance, the white colour defined as a burial of people and death in some cultures, was dissimilar in meanings in other cultures. In the USA for example - this was associated with marriage ceremonies and cleanliness (Weinschenk, 2011). Further, Schaefer (2011) claimed that bright colours were defined as happy and fun in many cultures.

- **Conceptual understanding**
  ‘Conceptual’ was defined based on ‘abstract ideas’. ‘Conceptual understanding’ meant understanding the ideas (Compact Oxford Dictionary & Thesaurus, 2009a; Longman dictionary of contemporary English, 2003a).

Marek et al. (2002) reported on 45 students (26 females and 19 males) between ages 5 to 13 and their conceptual understanding and cognitive developmental levels. They were verbally asked questions on a pre-and post-test, using an audiotape recorder to capture their verbal responses with 5 specific interactive science exhibits - ‘Pipes of Pan’, ‘Hot Air Balloon’, ‘Body Resistance’, ‘Bernoulli’s Principle Airfoil Lift’, and ‘Jacob’s Ladder’ at the Omniplex in the USA. The findings of Marek et al.’s (2002) research showed that students achieved a high level of understanding of the concepts of the exhibits. This required concrete operational thought (empirical-inductive or EI) rather than formal (hypothetical-deductive or HD) thought after pre-operational (PO) activities. Further, the three terms - EI, HD, and PO were cognitive developmental groups.

Allen and Gutwill (2004) reported that five common problems frequently occurred in the design of interactive science exhibits. The serious pitfalls were:
(1) Multiple functions overcame visitors such as a light exhibit with color mixing, reflection, and refraction.

(2) Multiple features interrupted or disturbed other visitors’ activity such as a spinning disc of sand exhibit. The visitors could make a pretty circle, spiral, wave pattern on sand.

(3) Open large scale options might encourage single users to impede the phenomenon by interactivity. For instance, a tornado exhibit which allowed many visitors to run around to disrupt the passage of air and water vapour.

(4) Interactive options might cause the crucial occurrence to be difficult to discover. For example, an original live beating cells exhibit where the visitors needed to have previous knowledge for using the microscope.

(5) Secondary functions could dislocate the primary one such as a sand trial exhibit (originally known as fading motion).

The visitors might prefer to increase the speed of the moving belt drive control rather than swing a pendulum of sand. These features were suitable for multiple options of top levels of interactive exhibit design. In addition, Allen and Gutwill (2004) believed that the science centres had interactive exhibits with an excellent reputation as good as those in arts, cultural and historical museums.

Rasmussen and Vicente (1989) stated that technological developments could make human-system interaction at the interface increasingly prone to errors in the learning process. The analysis of human errors was an important part of systems design and its relationship to learning processes. They considered that there were three adaptation processes for operators of each learning level, and these were:

(1) Knowledge-based control (searching information, solving problems and doing experiments).

(2) Rule-based control (affecting know-how).
(3) Skill-based control (developing behaviour). The human-errors could be improved by the basic design guidelines and action routines of operations.

For the conceptual understanding of interactive exhibits, Allen and Gutwill (2004) described the most common interactive features, calling them 'PAR' which were abbreviations from three words - e.g. ‘Physical’ (relating to activities on computer or symbolic media), ‘Adjustable’ (changing in options as simple as push an on/off button) and ‘Relevant’ (supporting the scientific discovery of the phenomenon directly more than requiring visitors to read graphic information). These features were combined together in a single exhibit.

- **Social issues**

‘Social’ means relating to join with human society and its organisation. The examples of social issues were e.g. unemployment and education (Compact Oxford Dictionary & Thesaurus 2009c; Longman dictionary of contemporary English 2003e). In addition, Berry et al. (2002) noted that the greeting performance e.g. bowing, kissing and hand-shaking became common social behaviours as they were accepted as part of the culture of that society.

Solving social interaction problems of cultural groups was improved by limited activities assigned to different people working together on the same task and improved the people's performance on commonly made errors (McFarlane and Latorella, 2002). Allen and Gutwill (2004) suggested that there was only a small group of the visitors - between 10 to 20 visitors - who discovered and suggested solutions to various study problems of interactivity in the exhibit.

For the relationship of visitors’ interactions in social issues, Watson et al. (2002, p.132) observed children who are May (aged 6), Laura (aged 7), and Ben (aged 8) through 25 interactive science exhibits - e.g. shadow play, mirrors, nail prints and musical/ sound area - at a children’s museum in Australia and they noted that,
“The children were helped by watching others, showing others and working as part of a team. There is considerable evidence that the children preferred working with other children. There is an indication that when the children were able to share an activity, they spent longer on that activity and were therefore more likely to investigate and learn”.

Another aspect of interactive exhibits use at the museum was mentioned by Hornecker and Buur (2006). They believed that devices which were adequate for use by one or a few people would need to be redesigned for use by many visitors. Exhibits which supported many visitors had the benefit that they could encourage people who were shy to join in with the other users and become part of a team. The Envisionment and Discovery Collaboratory (EDC) system was used to redesign a local bus route exhibit. People applied a finger or a pen to move and delete objects on the system. The system organised two groups of users for discussion in role-play to identify a new placement of stops and a new route for the bus.

Furthermore, Featherstone et al. (2009) claimed that an important achievement of science in British society was the British Science Association promoting key cultural establishments. Culture and leisure activities attract people to engage in science learning as a public activity. People are not only motivated by cultural considerations to make such visitors, but also they can be inspired by the scientific content and awareness of the personal benefits of visiting the establishment concerned.

In addition, the physical skills of particular visitors may be affected by certain issues use of left hand and left-handedness might occasionally affect for example the people’s interactions in social situations of various cultures. Kita and Essegbey (2001) claimed that many Ghanaian people may not point using their left hand, because this is a forbidden gesture, but they can use both hands together to point. However, Laland (2008, p.3579), who has explored gene-culture interactions in his research, argued that “But there are no cultures in the world in which left-handers are the majority...”. Left-handers are 10% of human populations who were commonly found in European-American cultures rather than in Asian cultures (Mandal and Dutta, 2001).
For instance, it may cause problems when teaching or when any writing activities are conducted which McManus (2003, p.308) remarked that “… teachers are expected to know which children in their class are left-handed, and that they should, in particular, seat them appropriately so that elbows are not bumped while writing”.

Another example is the Expat website (2014), ‘Living in Indonesia: A site for expatriates’. This reviewed Indonesian cultural habits and stated that Indonesian children practised right-handedness when they were very young. Also Indonesian people do not shake hands, or serve food and drink with their left hand as this is regarded as an unclean hand, only for use in toileting.

- **Emotional values**

“Emotions are essentially personal: different people will experience different emotions towards the same product. Whereas one person might feel attracted to a Volkswagen Beetle, another might find it boring. Because of this personal nature, it seems difficult, if not impossible, to find general relationships between product appearance and emotional responses” (Desmet et al., 2001, p.2).

Ekman et al. (1987) reported that the three expressions for each of the six emotions (happiness, surprise, sadness, fear, disgust and anger) were judged by members of 10 cultures - “The samples were from the Estonian SSR (N = 85), German (67), Greece (61), Hong Kong (29), Italy (40), Japan (98), Scotland (42), Sumatra, (36), Turkey (64), and the United States (30)” (Ekman et al., 1987, p.714). The results were obvious when the Western subjects were shown 18 Western people’ photographs – which were black and white photos, the faces of adult men and women between 30-40 years old, they accurately assessed the emotion of these photos. However when the Asian subjects were shown Western people’s photographs, they could not accurately assess the emotions for anger, disgust, or sadness (Ekman et al., 1987).
Norman (2004) showed the importance and influence of human emotion to the design of interaction devices. He pointed out that some people like to interact with roller coasters when they ride on them, although the roller coaster was scaring many of them. The two reasons, people liked to interact with them were people love fear and enjoy boasting about their riding of the roller coaster to other people. However, many people might ignore to ride it again or stop doing it.

Ekman (1993) reported that there were cultural differences related to the perception of emotion in the faces of others. The emotions as expressed in facial expressions were appropriate in the different social situations such as looking at strangers and their facial expressions then changing to angry and threatening. The various appearances of cultural emotion merged with languages. For example, there are many terms reflecting anger in English language such as in terms of personal characteristics e.g. testy, huffy, spiteful, in term of metaphors e.g. fed up, pissed off.

Additionally, Weinschenk’s (2011) viewpoint was that meaningful colours may influence the two cultural issues: visual culture and emotional values. Visual culture may interact with emotional values of facial expression in exhibits or any materials in the design were developed using colours that a culture regards as inappropriate. Allen and Gutwill (2004) believed that some exhibits might offer limited or boring functions as far as the visitors concerned. Furthermore, Bainbridge (1983) pointed out that if people operated something without time-pressure, they felt more able to cope with the task. On the other hand, when humans had more time pressure, they have opportunities for decision-making, refused room for options and fewer decisions can be made. Emotional values could be evaluated from the favourite of users. Also emotional values might be apparent in all four groups of interactive science exhibit’s classification. Some interactive science exhibits made visitors desire to participate in because the exhibits excited children enjoy and repeated children to interact with many times.

Padgham and Taylor (1997) noted that not only teaching and training appeared in the simulation systems, but also entertainment was mentioned
by the people as a significant emotional reaction. Some emotions generated were positive status - e.g. happy, grateful and hopeful about their achievements. On the contrary, some emotions were negative - e.g. sad, disappointed and regretful about unfulfilled achievements. Shibata et al. (1997) described human interaction with the non-human world - e.g. interactions with animals, fish, rocks, and trees. They evaluated these interactions by means of human knowledge and stored experience of life to date in human memory. The interaction of say a stone is mediated not by human verbal communication, but by sight, touch, and proprioception. However, the interaction between virtual or digital objects – e.g. animals, fish, and pets - may be enhanced from that of the real world object. This is because additional communication can be available if programmed into the digital device. The significance of this communication is that the additional perceptions can stimulate the emotions of the human through these interactions.

Wehrle and Kaiser (2000) reported that emotional expression in human interactions was acknowledged in recent years. This body of research appears in a number of key scientific disciplines and journals. They include computer science, computational intelligent system, psychology, and social sciences. The facial expressions strongly relate to the person underlying the emotions. So a person smiled because they were happy. However, a facial expression could have various meanings and more than one meaning - e.g. a frown by an audience due to cognitive difficulty could convey to the speaker the fact that they did not understand what he said. The frown of the listener could turn to one of anger, the speaker continued to fail to communicate anything meaningful.

Furthermore, Schaefer (2011) noted that the basic emotional translations could be understood by most people including others from various backgrounds of different cultures. The facial expressions and human emotions were shown as having universal meaning such as anger, fright, happiness and smile.
Finally, emotional values may relate to other cultural issues such as language issues (Ekman, 1993), and visual issues relating to the meaningfulness of colours (Weinschenk, 2011).

- **Age issues**

Cultures in the world should recognise the importance of age. Not only the young child, old people, young students and teenagers were in the groups of age issues but also pregnant women needed to get any offers for special privileges. Schneider and Cheslock (2003, p.8) remarked that “Children interact more frequently with hands-on exhibits than do accompanying adults”, but the age issues of culture issues was found in all groups of the interactive science exhibits. Hence, the author believes that science educators and the designers should be concerned to develop exhibits which are suitable to the ages of the users of the exhibits. Some exhibits might display signal words such as caution or warning to remind the users who the exhibits is to be used by.

For example, Roussou and Efraimoglou (1999) reported that the active stereo glasses might be not suitable for children. This is due to 3D glasses which could be too large for a small child's head, and of course expensive to replace if broken by a child. The children would need to control the stereo glasses, and would need both hands, or they might tie glasses with special knots to fit their heads. Also they might need to stand up in higher position to get the right viewing angle which might involve unsafe postures.

According to ASTC (2009, p.19), it reported that “Responding to an increase in the older population, science centers and museums are also offering programs targeted at senior citizens-about 29.2% worldwide reported that they offer such programs (30.6% in the United States)”. This report of ASTC (2009) showed that American culture is concerned to offer a special programme for their senior citizens or old people to interact with the exhibits at their museums of science rather than in other cultures.
Disability, Impairment, and Handicap

Barbotte et al. (2001) reported that the Geneva, World Health Organization (WHO) in 1980 defined the International Classification of Impairments, Disabilities and Handicaps (ICIDH) defined impairment, disability and handicap as follows.

Impairment means “Any temporary or permanent loss or abnormality of a body structure or function, whether physiological or psychological. An impairment is a disturbance affecting functions that are essentially mental (memory, consciousness) or sensory, internal organs (heart, kidney), the head, the trunk or the limbs” (Barbotte et al., 2001, p.1047).

Disability means “A restriction or inability to perform an activity in the manner or within the range considered normal for a human being, mostly resulting from impairment” (Barbotte et al., 2001, p.1047).

Handicap means ‘This is the result of an impairment or disability that limits or prevents the fulfilment of one or several roles regarded as normal, depending on age, sex and social and cultural factors’ (Barbotte et al., 2001, p.1047).

According to disabled people in cultures, Ladd (2003) wrote about ‘Understanding Deaf Culture: in search of deafhood’. He analysed that deaf persons were grouped into the type ‘disabled people’. Deaf people also think differently because they have a unique system of communication – their ‘sign’ language.

At present, most interactive science exhibits do not offer any special provisions for a particular group of disability. Frontier Economics (2009) reported that there are 81 science centres in the UK. Twenty six science centres support events for disabled people. Twenty two science centres managed activities for people with special educational needs. Disabled people or essential educational needs were 6% of general visitors. Featherstone et al. (2009) commended that professional engagers, researchers, and especially volunteers could get disabled people involved in public engagement activities in cultural sectors. These expert people could look after target groups such as disabled people, or other minority groups of
people. Occasional interactions of activities could be organised between independent adults, general schools, and particular families.

An illustration of what is possible even with severe disability is the life of the first woman pilot to fly with her feet, Jessica Cox. She was the first armless woman to gain a pilot’s certificate and listed in the Guinness Book of World Records in aviation history (Jessica Cox Motivational Services, 2011). She is a young Filipino-American who was born without arms, fingers, hands, or elbows. She gained the pilot license when she was 25 years old. She also can drive cars, play the piano, and play a martial art - Tae Kwon-Do, which she performs as a black belt (Castro, 2009). Jessica Cox’s story proves that the background cultures in some countries - such as in the United States where she grew up – can provide for disabled persons, the same level of freedom to do the skilful activities e.g. drive cars, and fly aircraft as for able bodied people.

This leads to the research question - ‘How many countries in the world have a similar culture and could produce their Jessica Cox?’ Nevertheless perhaps the story of Jessica Cox could stimulate and motivate the science educators and designers of many museums of science in the world to develop and improve interactive science exhibits to support these groups of disabled/handicapped people by optional features on their exhibits.

- **Gender issues**

“Sex refers to the biological and physiological characteristics that define men and women” (WHO, 2012, np). Comparing with, “Gender refers to the socially constructed roles, behaviours, activities, and attributes that a given society considers appropriate for men and women” (WHO, 2012, np).

The WHO (2012) described that males and females were defined in sex classification. For example of sex characteristics, women have generally smaller bones than men and hormone of human. Masculine and feminine were classified in gender such as women are not allowed to drive cars in Saudi Arabia and most women have the job of housework rather than men in the world.
From the literature review, many researchers referred to gender differences, as follows.

Brislin (1993) pointed out that males were more aggressive than females and from an early age in all cultures. He summarised that “Males engage in more rough-and-tumble play, attempt more often to dominate peers, engage in more physical aggression, exhibit more antisocial behavior, prefer television programmes with more aggressive content [where TV exists, of course], and depending upon context, are more competitive than females” (Brislin, 1993, p.294).

“The presence of others in the electronic game environment appeared to strongly influence the playing patterns of girls. When a particular station was filled with a group of boys, the girls were very hesitant to approach. If they did approach, they would usually watch for a few minutes and then walk away. The girls appeared intimidated by large groups, although it is likely that while watching, they were nevertheless actively involved in thinking about the games” (Inkpen et al., 1994, p.96).

Pedersen et al. (2003) reported that the gender differences in lateralisation of fine manual skills were discovered in the activity of ‘Threading nuts on bolt’, not in the activity of ‘placing pegs’. Using the times of the two tasks for the groups of female and male children, these were examined using means and standard deviations. The left-hand performance in the threading nuts on bolt task showed a difference between boys and girls but no distinction was found in the placing pegs tasks. From the Pedersen et al.’s (2003) report, it might claim that some cultural issues could be overlapped between physical skills such as manual skills and gender issues.

2.14 Summary
2.14.1 This chapter provides the main ideas to understand overall meanings of culture, cultural, and cultural differences. Every country in the world might have a different meaning for culture in their cultures. The definition of culture in various cultures might not have its equivalence, but it might be similar in some respects and different in others. There may be differences in the
meaning of the cultural components e.g. languages, artefacts, attitudes, beliefs, and social behaviours in relation to the same word in other countries (Brislin, 1993; Laroche, 2008; Serpell, 1976; Trompenaars and Hampden-Turner, 1997).

2.14.2 The understanding of various cultures could be expanded by the dimensions of the cultural models from many researchers such as Hall (1959), Hall and Hall (1990), Hofstede (2001), Trompenaars (1993), Trompenaars and Hampden-Turner (1997), and Victor (1992). These researchers gave many examples of distinctive cultures. The examples showed that various cultures were important for learning and understanding which most people could apply when they interact with other cultures.

2.14.3 The background information of science museums describing the importance and relevance of science and technology to everyday life. Currently, several countries around the world have established science museums in their countries. Visitors to these establishments have received scientific knowledge from these museums.

2.14.4 The basic definitions of interaction, interactive science exhibits, and interactive science and technology exhibits (ISTEs), including existing design guidelines were described in this chapter.

2.14.5 Classifications of interactive science exhibit were found from the literature review which were developed by several researchers such as Afonso and Gilbert (2007), Boisvert and Slez (1995), Gilbert and Stocklmayer (2001), Ghose (2000), and Sandifer (2003). Why are the classifications of interactive science and technology exhibits so important for today and the future? The answer found in a combination of two factors:

1) Science and technology presently have crucial roles in the schools and museums of certain countries, include contributing to developing their national industrialisation, economic growth and development (Brooks, 1994; Burbules and Lin, 1991; Ergas, 1987; Said, 2000; UNESCO, 2013).
2) Interactive science exhibits are increasingly a well-known and highly thought of kind of exhibit to establish at the science museums around the world (ASTC, 2009).

These two factors combine to support the classification of interactive science exhibits as a priority task and for the future. Such worldwide science museums could continuously develop their interactive science exhibits based on appropriate classifications to encourage their visitors’ learning and understanding of science. This to be achieved through various perspectives on learning science at the museums of several researchers – e.g. Bamberfer and Tal (2007), Braund and Reiss (2004), Dierking and Falk (1992), Falk and Dierking (2000), and Falk and Storksdieck (2005).

2.14.6 A brief review was given of existing design guidelines for developing interactive science exhibits taking into account cultural influences. Many present day designers of interactive exhibits do not take into account worldwide cultural issues in their designs.

2.14.7 The relevance between culture and science education was clearly acknowledged by researchers e.g. Hofstede (2001), Marcus (2006), and Millar (1996). They described culture as important to education and design, and interactive science exhibits should always be examined in terms of cultural differences. Also numerous cultures of globalisation in the world could be applied to develop and improve interactive science exhibits for international visitors and local visitors promoting as universal access as much as possible. It underlines the fact that the science museums and science centres in the world should be considering the various cultures of local visitors and international visitors for learning science exhibits.

Globalisation will involve museums of science receiving many international visitors, and they have varying backgrounds in cultural issues. This will have an impact on the level of understanding of its visitors.

2.14.8 The 10 dimensions of cultural issues relating to human-interaction design were found from the literature review: physical skills, technologies issues, language issues, visual cultures, conceptual understanding, social
issues, emotional values, age issues, disabled people and gender issues. The literature review offers a wider consideration of these cultural issues in terms of their dimensions rather than providing key word searches using several search engines. The validity of these dimensions will be evaluated by the museums of science and will address them in case study 2 - ‘the dimensions of cultural issues relating to interactive science and technology (ISTEs)’.
Chapter 3
Research methodology

3.1 Introduction

Chapter 3 provides the overall plans of the research methodology and methods. The research stages outlined in this chapter are data collection, cluster analysis and method of survey, and triangulation. The elements of the research study are divided into three case studies. This chapter also describes which case studies are used to address which research questions.

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<td>RQ 4 How to define the relation between the cultural differences and interactive science and technology exhibits, and what categories of cultural differences are there?</td>
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<td>RQ 5 What interest have the experts of the museums of science in culture influencing the use of interactive science and technology exhibits; and which cultural issues do they believe are the most important?</td>
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<td>RQ 6 How do the characteristics of the interactive science and technology exhibit take account of cultural differences which affect learning?</td>
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<td>RQ 7 What are other factors which significantly contribute to cultural differences in learning to use and using interactive science and technology exhibits? For example, age, gender, and educational levels. Why are these factors related?</td>
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<td>RQ 8 How can interactive science and technology exhibits be developed to capitalise more successfully on cultural differences?</td>
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Table 3.1: Research questions in chapter 3
3.2 Background

From the background research in chapter 1, considering the Shake Hands 3-D reflections exhibit of MOSI in the UK and the Real Image exhibit of the NSM in Thailand, the assumption was made that cultural differences would significantly influence the visitors’ learning from interactive science and technology exhibits (ISTEs). For an example from this hypothesis of the cultural issues, at present, many ISTE’s have been developed and most of them are more suitable for home visitors than overseas visitors. These cultural issues might have an effect on the overseas visitors’ understanding of ISTE’s, this being apparent by their different perceptions to those of home visitors. The visitors who have different cultural backgrounds may benefit from consideration of these cultural differences and have a greater understanding of ISTE’s through their interactions.

3.3 Aims and objectives

This chapter describes the way that different methods were assigned in the research design of this thesis. The overall aims in this chapter are to establish the research paradigms for investigating the cultural issues of interactive science and technology exhibits. In general, the objectives of this chapter were to:

► Identify and describe the research methods to be applied within this research.
► Describe the limitations of the methods used.
► Identify the research questions addressed by the various methods used.
► Develop three case studies which adopt different methods to address and answer the research questions.

3.4 Methodology

As a definition of methodology, “Methodology is the study of method. (‘...ology’ means to talk about or study something, so ‘methodology’ means to talk about or study method.)” (Thomas, 2009, p.70).
Saukko (2003) claimed that ‘methodology’ originates from the Greek word ‘logos’, meaning knowledge which was different in meaning from the definition of ‘methods’. Methodology which used various practical tools or methods in the real world was widely undertaken for investigations in philosophy and political engagement in order to achieve a specific research approach.

Methodology is ‘research design’, which is a plan to answer the research questions. All components in the research - such as purpose, questions, approach and methods - can be integrated and organised to create a successful research project (Thomas, 2009). The research questions and methods were created by using the research methodology explored in the literature review.

**3.5 Triangulation in research paradigm**

“‘Triangulation’ is a process of verification that increases validity by incorporating several viewpoints and methods. In the social sciences, it refers to the combination of two or more theories, data sources, methods or investigations in one study of a single phenomenon to converge on a single construct, and can be employed in both quantitative (validation) and qualitative (inquiry) studies” (Yeasmin and Rahman, 2012, p.156).

Cohen et al. (2011) pointed out that mixed methods serve to enlarge quantitative and qualitative research in terms of the existing paradigm where “A paradigm is a way of looking at or searching phenomena, a world view, a view of what counts as accepted or correct scientific knowledge or way of working” (Cohen et al., 2011, p.5).

Jick (1979) remarked that the use of the triangulation technique which offered multiple viewpoints provided preferable accuracy and researchers could justify various types of data collections of the same phenomenon.

Furthermore, Hammersley (2008) emphasized that the triangulation technique has a role with mixed methods in integrating both quantitative and qualitative research methods. For instance, an inductive research approach
may be notably combined by using quantitative data such as data collection in the quantitative form and then applying the standard format of a qualitative report when using qualitative research.

Denscombe (2010) explained several kinds of quantitative data. For example, 'nominal data' was the lowest level of the quantitative data which categorised the members of things in particular groups, such as male/ female or White/ Asian/ African. ‘Ordinal data’ inferred data in ranking order, for example data from a Likert Scale. ‘Interval data’ was ranked on a time scale such as years 1966, 1986, and 1996. ‘Ratio data’ showed highest level data in terms of mathematical calculations such as distances and incomes. ‘Continuous data’ measured small incremental units such as in weight, age, and height of persons Denscombe (2010).

3.6 Case studies supporting research questions

Yin (2009) defined a case study as a particular example, which clearly gives the reader a perception of a real person carrying out activities in a real world situation rather than a person conducting synthetic activities based on abstract principles or theories. In addition, Cohen et al. (2011) pointed out that the case study was a kind of style in educational research. Other styles of educational research are experiments, action research, and virtual worlds.

A case study is generally designed to represent an individual example rather than a common principle (Nisbet and Watt, 1984). A case study defined as a “generic term for the investigation of an individual, group or phenomena” (Sturman, 1997, p. 61). Sturman (1999) cited the case study as an excellent vehicle to investigate human interactions with other people, including other factors which govern the human behaviour. Further, Cohen et al. (2011, p.289) commented that “Case studies can establish cause and effect (‘how’ and ‘why’)”. Also causes and effects could be deeply observed in real contexts which were taken to apply in each case study (Cohen et al., 2011). Yin (2009) recommended that case studies should be undertaken in preference to a single case. These case studies could be used to describe qualitative data and mixed methods research. Several tools for data
collection and variant sources of evidence could also be applied in case studies.

The application of case studies is important for this research project. The results from the case studies will afford evidence from the real world from several groups of participants, such as PGCE students, who are training as teachers in the UK, experts of the museums, and visitors. This evidence addressed the research questions. Additionally, this research project has three main case studies which gathered data by different methods to answer the research questions. A triangulation method will be used which aims to support the reliability and validity of the research findings.

3.7 Reliability and validity for the research assessment

The two terms - reliability and validity - are important for the assessment of acceptable findings in academic research which are described as follows.

3.7.1 Reliability

Reliability is a test relating to when the experiment was done on different occasions and that it produced the same or similar results (Thomas, 2009).

Additionally, Cohen et al. (2011) pointed out that synonyms of ‘reliability’ were ‘replicability’, ‘consistency’, and ‘dependability’ which could be repeated in variant instruments, with several groups of respondents, and with frequency in similar contexts. For example, the similar results relating to accuracy and precision remained reliable in research into dimensions e.g. distance and height measured, but other features could not produce the same consistency of results e.g. musical ability. Evan (1968) pointed out that it was as a rule easier to evaluate reliability than validity. Reliability could be measured without validity. The measurement of reliability was conditional upon consistent test results. If validity could not be established, reliable testing could not be measured.

Given (2008, p.446) defined inter and intra-coder reliability as follows: “Intercoder reliability involves at least two researchers’ independently coding
the materials, whereas intracoder reliability refers to the consistent manner by which the researcher codes”.

Hruschka et al. (2004) pointed out the fact of inter-coder reliability of text, where two coders may interpret the same set of texts better than using only a lone coder. The bias and random error may increasingly produce risk for the task of interpretation, if the texts were interpreted without other coders. On the contrary, Hayes and Krippendorff (2007, p.79) remarked about coding scale points or the number of categories:

“This assures that reliability is not biased by the difference between what the authors of the coding instructions imagined the data may be like, and what the data turned out to be.” However, from this point a situation may increase inter-coder error, if more than two coders have bias in interpreting the data.

**3.7.2 Validity**

Guion et al. (2011, p.1) stated that,

“Validity, in qualitative research, refers to whether the findings of a study are true and certain - ‘true’ in the sense that research findings accurately reflect the situation, and ‘certain’ in the sense that research findings are supported by the evidence”.

Validity could be engaged with various phenomena and related to empirical investigations (Lafaille and Wildeboer, 1995). Further, validity is an essential requirement for achieving effective research. On the other hand, if invalidity was found in any part of the research, it would render the research valueless (Cohen et al., 2011).

Thomas (2009) stated that validity comprises of two main types – ‘instrument-based validity’ and ‘experimental validity’. ‘Instrument-based validity’ was measured including content validity (this validity may be concerned to cover all of the necessary content), ‘predictive validity’ (this validity to predict a test of fair outcomes), and ‘face validity’ (this validity’s self-evident to the person being tested). ‘Experimental validity’ could be created as a test of the experiment in psychological and social life. An
elimination of non-reflection in the ‘experimental validity’ was managed and called ‘internal validity’.

Additionally, Matsumoto and Yoo (2006) pointed out that the validity of cross-cultural research was to explore and understand the similarities and differences of members in their cultures by means of four main phases. The first phase involved the comparisons of the member groups between their cultures for these elements which were found to be different. The second phase was the identification of the important dimensions of culture e.g. Hofstede’s (1980) renowned dimensions of culture’s consequences. The third phase examined individual cultures and sought to explain the differences in variant cultures using the theoretical models of cultural studies. This phase is limited to empirical testing. The fourth phase was to define and investigate the linkages between the hypothesis models and the empirical research of cultural differences.

However, this research was limited because it could not cover all the validity issues of cross-cultural research as recommended by Matsumoto and Yoo (2006). It could be argued that the case study might not manage to identify all the research comparisons of the cultural issues relating to ISTEs in each culture of the 8 main geographical regions of cultural differences as defined by Murdock (1983). This is because of the limited time for this research, the small number of science museums in particular cultures of each country, and a lack of participation of the experts in individual cultures of the world. Bearing in mind these limitations, this research aims to establish, investigate, and understand the cultural issues relating to ISTEs in terms of their ‘dimensions’, to a greater extent than comparing the cultural issues between several different cultures.

The relation between reliability and validity can be shown in the four possible outcomes of darts hitting on a dart board (Shuttleworth, 2008; Trochim, 2006a) in Figure 3.1.
3.8 Research methods

The purpose of this section is to describe the research methods within this research. The reasons for using these main methods in this research were:

3.8.1 Network analysis

Network analysis began to be used to support users in internet and social networks (Bliss et al., 1983). Canright and Engø-Monsen (2008, p.5) indicated that “… whenever the objects of study are discrete, and the relations between the objects can be identified and are of interest, a network model is appropriate and useful”.

Cohen et al. (2011, p.448) suggested that “Essentially, network analysis involves the development of a system of categories by the way of classifying qualitative data and preserving the essential complexity and subtlety of the materials under investigation”. A network of concepts which were contained in mind maps could link any idea to any another idea (Davies, 2010).
Additionally, Ramalingam (2006) stated that mind maps are useful as a non-linear method of organising information and applicable for both ‘individuals and groups’. The intention is to make a connection in thinking by using a graphical technique in several kinds of study.

The usefulness of network analysis, such as mind mapping techniques for grouping masses of qualitative data, was seen from the output of the searches in the literature review, which included internet based searches.

### 3.8.2 Cluster analysis

Cluster analysis is a statistical method. Clustering was defined as a data mining process to identify and discover patterns in the data. This was also one of the most advantageous methods for distributing data into groups (Fayyad et al., 1996). The groups of data were organised to reveal similar and different patterns in the clustering process. The main concern being that the sensible groups were discovered to be useful (Guha et al., 1999). Furthermore, Halkidi et al. (2002) pointed out that the quality of the clustering results was evaluated by comparing the arrangement with that of the experts who evaluated the clustering groups. These methods were known as cluster validity methods which were used to evaluate the results of the evaluation of the experts in the quantitative methods. Therefore the essential reason for using cluster analysis was to develop a new classification of ISTErs which significantly correlated with the dimensions of the cultural issues.

### 3.8.3 Interviews

Although a conversation might be similar to an interview, interviews do not involve conversation and relate to the understanding of a theme which is believed as fact and event (Denscombe, 2010; Denscombe, 1983; Silverman, 1985). Drever (2003) described the pros and cons for selection of interviews or questionnaires as follows.

- Interviews provide high-quality information from interviewees to clarify answers.
- People spent too much time in the interview which occasionally took 45 minutes to an hour plus the time for travelling and social talk.
- The processing of the interviews takes time too.
• Compared with questionnaires, the response may be 100-200 people per time; some people may not return the questionnaire. The questionnaire data easily transfers from a response sheet to a table grid.

Denscombe (2010) indicated that interviews differ from conversations. Thus most people did not have difficulty having their own conversations whoever was asking the questions or giving the answers. On the contrary, interviewing is not really a simple exercise to conduct. It requires suitable preparation, appropriate planning, and sensitivity to interactions between those involved in the interviews. In addition, Drever (2003) pointed out that an interview required skills suitable for a formal meeting for both parties concerned with a particular intention. In light of this information, an interview method was regarded as an appropriate method to generate information from the experts at the museums of science concerning the cultural issues relating to ISTEs.

3.8.4 Paper-based questionnaire

Questionnaires are a research tool designed to generate information for analysis. They provide identical sets of questions including images which might be more applicable than words. Questionnaires can directly collect the data relating to the attitudes of people (Denscombe, 2010).

Questionnaires with two kinds of scale were used. They involved closed-ended questions and open-ended questions. Both had advantages and disadvantages so far as the research and the researchers were concerned (McQueen and Knussen, 2002).

Closed-ended questions which were a dichotomous question were presented to respondents with only two choices for their response e.g. yes or no, and male or female (Cohen et al., 2011). Dichotomous questions were used when there was a need to collect data on the same topic several times. This kind of question could be declined if it caused respondents difficulty and they guessed the answer (Sudman and Bradburn, 1982). Multiples-category scale or multiple choice questions provided three or more choices for the respondents, and the rating scales were indicated from low to high, positive
to negative, and strong to weak (McQueen and Knussen, 2002). Ranking the order of questions was used where a comparison of values was required. This ranking scale differed from the rating scale where the values were designated as choices and were not related to each other (Ovadia, 2004).

The Likert scale as a rating scale was invented by Likert (1932) to measure the level of agreement between people for a given statement or series of statements e.g. the question was “How would you rate the service and cleanliness of the hotel?” (Bell, 2005, p.142). An example of the use of the Likert scale for the answer was excellent, very good, good, satisfactory, and less than satisfactory. Also it could be used to generate the appropriate number for ranking e.g. three, five or seven-point scale to indicate the rank order (Bell, 2005). In this thesis, two Likert Scales were differently chosen to use as a 7 point in Case Study 1 and a 5 point in Case Study 3. The 7-point response was used to identify a new classification of ISTE (Interactive Science and Technology Exhibits), because this response was preferred by the author and the expert from the NSM in Thailand who has experience of developing interactive science exhibits over several years. The 5-point response was used in the paper-based questionnaire, which was completed by the visitors of varying ages. A 7 point scale may cause confusion to primary students who are very young visitors and hence the 5-point scale is an appropriate scale for visitors to respond with.

Thomas (2009) described how open-ended questioning was a kind of question where the respondents could be given answers derived from the respondents preferred opinions. Then the researchers needed to gather the information precisely for subsequent analysis. For example, a question was asked of participants, “What are you feeling about the National Lottery?” (Thomas, 2009, p.162). In addition, the researchers should possibly encourage the respondents to complete the questionnaire (Bell, 2005).

Respondents not returning the survey or not responding create problems with the research. In this case – following questions being unanswered, it posed the question – was it practical to distribute the survey again? (Moser and Kalton, 1971).
Cohen et al. (2011) advised that if a paper-based questionnaire was created, it could also be applied by means of an internet-based survey. Consequently, this research used a paper-based questionnaire, administered in a variety of ways to collect information from the respondents, trialled with PGCE students before being used with museum visitors.

3.8.5 Rubric scales
The College of New Jersey or TCNJ (2013, p.1) defined that “Rubrics are developed to assist faculty in rating qualities of learning outcomes ... A rubric can be defined as a descriptive guideline, a scoring guide or specific pre-established performance criteria in which each level of performance is described to contrast it with the performance at other levels”. Jonsson and Svingby (2007) reported that the use of a rubric as a new research issue was published in only 7 articles before 1997. One third of the 75 articles reviewed in Jonsson and Svingby’s (2007) research had rubric usage in school education.

Rubric scales are of 4 types –‘General’ or ‘Task specific’ and ‘Holistic’ or ‘Analytic’.

‘General’ rubrics provide criteria across several levels of performance which can provide various performances on the same Rubric but the feedback may not provide narrow and in depth information.

‘Task specific’ rubrics provide a score for a specific task which is a more reliable assessment but they have difficulty in providing a rubric scale for over all performances (Schreyer Institute for Teaching Excellence, 2013; Teaching Commons, 2013).

‘Holistic’ rubrics contain a single dimensional score which can identify an overview of personal achievement and score rapidly. They do not provide a more informational scale.

‘Analytic’ rubrics provide several dimensions of score giving more information and across different levels of performance listed but involve too much time to generate the score (Zimmaro, 2013).
Rezaei and Lovorn (2010, p.30) commented about a rubric used in a writing assessment that “In the same way, using a rubric may not necessarily be better than not using one. The history of writing assessment shows that achieving high reliability in writing assessment is not easy, and we should be careful not to sacrifice validity to achieve higher rates of reliability.”

3.8.6 Online questionnaire
The main reasons for using this method of internet-based surveys are set out in the following.

An internet-based questionnaire is more advantageous than a paper-based questionnaire because it can collect data from more than 500 participants in a cheaper form than sending and returning surveys using the postal service. The costs of design and development should be considered (Watt, 1997). The higher response rates should be taken into account (Glover and Bush, 2005). Print costs and postage were not incurred in the internet based-survey, which is lower cost than mail surveys (Jones and Pitt, 1999). The online survey was also faster than a mail based survey. Also the online survey could make use of multi-media presentations of information such as audio and video which can provide for interactive surveys (Fricker and Schonlau, 2002). Online surveys reported higher response with fewer missing values and production of higher quality data or generation (Deutskens et al., 2005).

Other reasons for using an online survey was that distribution was much simpler and quicker and involved participating staff in far less time and effort administering, completing and returning it. It was simpler to get the questionnaire into multiple science museums of around the world. These survey methods may be convenient for helping the experts in several museums to provide their feedback quickly and not spend their time sending the completed questionnaires back in the mail. In some cases a fax machine was used to send a paper-based version of the questionnaire.
3.8.7 Video recording observation

Simpson and Tuson (2003) remarked that an observation was a kind of data collection by means of which several forms and contexts of social interactions could be recorded by researchers. Other kinds of data could be captured in a highly flexible form. Further, another useful aspect of observation is where video recording captures non-verbal actions, in a contrived setting created by an observer and followed by analysis of the natural behaviours (Bailey, 1994). Additionally, Simpson and Tuson (2003) asserted that observation should be considered as one form of purposeful decision making. The observations chosen were selected on the basis of those providing the most useful data and types of study. The techniques addressed the research questions and then the processing of data followed.

However, the main reason for using video recording of observations was to remove the need for instruction as required for directed observation. A digital video recorder was used to capture such behaviour of participants at the chosen museums of science. It was also used to investigate participants’ interactions with ISTEs. Other advantages of the video recorder were that it could zoom in or out, take short movies including close ups of the interactions between participants and the ISTEs. However, the sound from multimedia presentations and speakers of other exhibits at the museum might interfere with the capturing of the conversations of the participants.

3.9 Ethical considerations

“Ethics can be defined as involving the systematic application of moral rules, standards, or principles to concrete problems, through some authorities” (Davison, 2002, p.1). Ethics was a crucial consideration in this research, because the participants in the research will be people. The definition of ‘Ethics’ given by Davison (2002) was the one which was the most appropriate and helpful definition for this research.

The guarantee of research ethics in social researches was very important. Denscombe (2010) indicated that participants should normally be anonymous. They should voluntarily agree to participate in the research activity and understand clearly their own involvement in the research topic.
Also they should be assured that the data from the research will be kept in a secure environment.

In addition, all closed and open-ended questions for the case studies were developed with improvements from the supervisors of this research. This process ensured confirmation and clarification of ‘rightness’. The questionnaire administered to the visitors’ concerning their social interaction was submitted to the ethics committees and approved by the committees of Loughborough University, before copies of the questionnaire were distributed for use at the museums of science. In addition, the ethical considerations of this research took full account of the Ethical Policy Framework of Loughborough University (2013) as follows.

“Researchers must work with honesty, accuracy and rigour, and accept their professional duty to understand the ethical implications of their studies, especially those involving human participants, animals, risk to the environment and the use of sensitive data. All researchers should declare any real or potential conflicts of interest at the earliest opportunity, including those associated with publication” (Loughborough University, 2013, p.4). The evidence of ethical approval for this research may be found in Appendix 12.

3.10 Research design linking with research questions

“A research question is a logical statement that progresses from what is known or believed to be true to that which is unknown and requires validation” (Lipowski, 2008, p.1668). Punch (1998) proposed that the appropriate research questions were those that were clear (simple to understand and unambiguous), specific (answers were directly focused to generate), answerable (data shall be collected to answer the research questions), substantively relevant (produce worthwhile results) and interconnected (a coherent form linked in a meaningful way to more than one question).

In addition, meaningful questions should encourage the researcher to generate new topics for learning new knowledge and generating different views. Three phases were involved in addressing the major research
questions: asking interesting questions, choosing the appropriate question for the research, and connecting the question into an experimental hypothesis (Lipowski, 2008). The simple research questions might initially be identified through various words which are of interest to the researchers. This could be done within at least three groups of studies such as the analytical, the more general, and the developing studies. Several common but significant words of research focus could be used such as address, aim, analysis discuss, and purpose (Bredmar, 2013).

In general, the outlines in this section which follow explain a research design where the methods used relate to the research questions. The eight main research questions were developed and created to generate answers which would support the research topic. In particular, the following chapters describe in more detail each case study and it connects to the research questions.

Research Question 1
What is culture, and what is the meaning of cultural differences?

The first question shall consist of two main words – ‘culture’ and ‘cultural differences’. These words particularly emphasise the intellectual ideas rather than the practical issues involved. The first word is culture which appears in the research topic,

“A study of the importance of cultural factors in the user interaction with, and the design of, interactive science and technology exhibits in museums”.

The second word, cultural differences shall be formed to expand the meaning of culture by using the fact that in the real world there is more than one culture. Also cultural differences may influence visitors at the museums of science around the world such as learning and understanding in interactive science and technology exhibits (ISTEs) in variant ways. Thus the first research question shall explore the definitions of culture and cultural differences from the literature review which was described in chapter 2.
Research Question 2
What is meant by interaction, and what is an interactive science and technology exhibit?

The second question comprises two main words - ‘interaction’ and ‘interactive science and technology exhibit’. For the first word ‘interaction’, it is a noun and it is transformed into an adjective - ‘interactive’ in the English language. Also ‘interactive’ is a part of the word ‘interactive science and technology exhibit’ which is retrieved from the research topic. This question is to be addressed by the literature review which provides a meaning for ‘interaction’. The second word – ‘interactive science’ and ‘technology exhibit’ shall be defined by the explanations in the literature review. Hence, the second research question shall provide the meanings of ‘interaction’ and ‘ISTEs’, and describes these words in chapter 2.

Research Question 3
Why is the classification of interactive science and technology exhibits so important for today and the future; and what classifications are there?

From the literature review in chapter 2, it was apparent that most of the science museums had increasingly chosen to have interactive science and technology exhibits (ISTEs) in their museums (Allen and Gutwill, 2004; Friedman, 2000; Haywood and Cairns, 2006). Thus this third research question starts by considering the characteristics of ISTE in term of their classification. In particular, in relation to the existing characteristics of the installed ISTE’s the latter will be defined. The question sought out the answer to reveal what classifications were significant so far as the museums of science and their visitors are concerned. Then the question requires an exploration of the classifications of ISTE’s by other researchers as ‘what classifications are there?’ The existing classifications of ISTE’s of previous researchers such as Ghose (2000), Gilbert and Stocklmayer (2001), Sandifer (2003), and Afonso and Gilbert (2007) which address the third research question was identified in the literature review (reported in chapter 2).

The new classification of ISTE’s based on cultural differences will be established from the previous researchers’ findings by using the methods
such as Likert scale, cluster analysis, and inter-rater reliability. Also the paper-based questionnaire of ISTE classifications relating to the cultural issues will be designed and investigated by PGCE students who are science teachers in the UK and by the experts at the science museums. Boisvert and Slez’s (1995) ISTE classification was found after the paper-based questionnaire had been prepared and distributed. Therefore, the answers to this research question will be described in more detail in chapter 2 and will be analysed in case study 1 in chapter 4.

**Research Question 4**

*How to define the relation between the cultural differences and interactive science and technology exhibits, and what categories of cultural differences are there?*

The fourth question related to the characteristics of ISTEs which were categorised according to interactions caused by cultural differences. This question sought answers regarding the relation between cultural differences and the example ISTEs at several museums of science. A study of science education was done previously by the author of this thesis, Awsakulsutthi (2009a; 2009b; 2009c). This previous work was used to identify 6 cultural dimensions in the example ISTEs. Further, the interview results from the experts of science museums in the UK and the NSM in Thailand found more dimensions for the cultural issues relating to ISTEs. The process of finding the answer shall be explained in more detail in case study 1 of chapter 4.

**Research Question 5**

*What interest have the experts of the museums of science in culture influencing the use of interactive science and technology exhibits; and which cultural issues do they believe are the most important?*

The fifth question restates the issue concerning cultural differences and the interactions with ISTEs caused by these cultural differences. Three main methods were used to collect data relating to this question.

1) Network analysis identified 10 dimensions of cultural issues.

2) The use of an online questionnaire.
3) The validity of ISTEs relating to the cultural issues at the museums of science. The six previous dimensions of the cultural issues from case study 1 were joined with the four new ones. These were dimensions of the cultural issues which were identified from the literature review by using keywords, such as culture relating to interaction, cultural difference relating to interaction design, and cultural dimensions relating to interaction design.

Several search engines were used e.g. Library Catalogue Plus of Loughborough University, Google, Google Scholar, Bing, and Microsoft Academic Search via the internet. The process of the keywords search and analysis generated all 10 dimensions of the cultural issues which were described in case study 2 in chapter 5. The internet-based questionnaire generated the answer from the replies provided by the experts of many science museums worldwide. They were willing to share their views about the cultural issues. The literature review provided the background to the cultural regions of the world and this information was used to develop the online questionnaire. The questionnaire was developed from the results of the online survey. Also a reference letter from the research supervisors was attached to the emails which were sent to individual experts at several science museums worldwide. The feedback of results from the experts who responded to the online survey was used to classify these experts’ museums in terms of the cultural differences and geographical regions - Murdock (1983) and the United Nations (2009). Further, the validation of ISTEs relating to these 10 dimensions of the cultural issues at several museums of science in the UK and the NSM in Thailand was undertaken. Several examples of ISTEs from these museums were categorised into the different dimensions of the cultural issues. The fifth question was explained more fully in terms of the methods used to achieve the answers in case study 2 of chapter 5.

**Research Question 6**

*How do the characteristics of the interactive science and technology exhibit take account of cultural differences which affect learning?*
The sixth question explored the characteristics of ISTEs which impact on learning and take account of cultural variation. This question followed on from and built upon the previous results of case study 2, it researched and explored the learning effects. Three methods were applied to find the answers to this question such as literature review, paper-based questionnaire, and video recording of observations. The results of the literature review of the ISTEs relating to the cultural differences affecting learning were used. Then museums of science were contacted and one of the museums which was most suitable was selected to be involved with this aspect of the research. From the examples of ISTEs in the museums, one was chosen and was developed as a basis for a paper-based questionnaire for use by the participants. The sixth question and its result was described in more detail in case study 3 in chapter 6.

**Research Question 7**

*What are other factors which significantly contribute to cultural differences in learning to use and using interactive science and technology exhibits? For example, age, gender, and educational levels. Why are these factors related?*

The seventh question relates to research question 6. It refers to other factors which contribute to cultural differences such as age, gender, and educational level which may affect learning to use ISTEs. The answer to this question was generated by discussion using the findings from the literature review, results of case study 1, case study 2 and case study 3. It might need to use all of these case studies in order to provide a comprehensive examination of these factors. The seventh question is described in more detail in the discussion section of chapter 7.

**Research Question 8**

*How can interactive science and technology exhibits be developed to capitalise more successfully on cultural differences?*

The eighth question was closely allied to the purpose of this research which was an investigation into the cultural difference and their impact on the use of ISTEs. For example, the Real Image exhibit relating social issues to the cultural issues discussed in Chapter 1. On the other hand, this question
began by using the word ‘how’ to relate to the exploration of ways to improve the ISTEs taking into account the cultural influences. Hence, it might be concluded that all three case studies were essentially seeking to create guidelines for ISTE developments by supplying information about cultural variation and its impact on ease of use, ease of learning of ISTEs, and so on. The guidelines would aim to support the experts at the museums of science in the world for the improvements of ISTEs. It would be concerned with the 10 dimensions of cultural influence in the future. The answer to the final research question will be described in chapter 8.

3.11 Organisation of the study

This research was planned with the use of triangulation methods to investigate the cultural issues within the three case studies. The research results were generated using the three case studies, involving several methods. A triangulation model of the three case studies is shown in the following figure.

Figure 3.2: Triangulation model of the methods used in the three case studies
The various aspects of the design framework in each case study were developed in order to gather data in terms of the dimensions of the cultural issues relating to ISTEs. Each case study has collected data from different groups of participants who might originally share various cultural aspects connecting through the cultural issues in terms of the 10 dimensions. The methodology used in these three case studies can be described as follows.

3.11.1 Case study 1: Exploring the cultural issues and classifying interactive science and technology exhibits

Case study 1 investigated the evidence that the classification system(s) take into account the effect of cultural issues on their design and use between the ISTEs' classifications and the cultural issues. The design framework of this case study provides for four phases as follows.

Phase 1: The cultural issues relating to ISTEs shall be explored by revising a previous MA study conducted by the author (Awsakulsutthi, 2009a; 2009b; 2009c).

Phase 2: The existing classifications of ISTEs will be identified.

Phase 3: A new classification of ISTEs will be developed with particular reference to the cultural issues and will assess whether the existing classifications of ISTEs are appropriate.

Phase 4: The experts' interview shall provide their ideas about the cultural issues which they believe are relevant to the design and use of ISTEs.

**Target populations in case study 1**

In case study 1, the participants had a background of scientific knowledge associated with general science subjects relevant to the examples of ISTEs. Two kinds of participants were chosen to participate in this study as follows.

- Science teachers
- The staff or officers from science museums

This activity addressed the issue of the experts’ opinions, they formed a small group. The participants in this small group comprised a pilot group
considering the six dimensions mentioned in Chapter 4. These experts were invited to comment on the classification of ISTEs into four classes defined by the cognitive aspects of the relationship to visitors using ISTEs. These experts were also invited to comment on the degree to which the six dimensions adequately represented the cultural issues.

**Sampling of case study 1**

The sample group were postgraduate students who remain anonymous and do not provide any personal details e.g. their age and any educational backgrounds of their school, colleges, and university. Two sampling groups of participants were selected to participate in this study as follows.

- PGCE students of the year 2011/2012 from Loughborough Design School (LDS). These PGCE students had experience of teaching science subjects in the UK schools and became the participants in this case study. The PGCE Teacher Training is explained on the Design School’s webpage of Loughborough University (2014). It is a full-time one year course of 36 weeks for the secondary school teachers in Design and Technology Education preparing to teach pupils aged 11-18 years old.

- Educators from the museums of science in the UK and from the NSM in Thailand.

**Data collections of case study 1**

The data collections in this case study were divided into 4 phases:

Phase 1 researched in depth the information relating to the cultural issues and their effect on ISTEs’ design and use.

Phase 2 searched for existing classifications of ISTEs in the literature review.

Phase 3 collected the feedback of the paper-based questions about the existing classifications including the new classification of ISTEs from PGCE students and the experts.
Phase 4 interviewed the experts in the museums of science in the UK and the NSM about their ideas regarding cultural issues relating to ISTEs. The processing of the data collected in these 4 phases is further described in the following:

- **Phase 1**: This involved the data collection from the previous study and the literature review. Various cultural issues relating to ISTEs are re-examined from the MA study of the author, Sumath Awsakulsutthi (Awsakulsutthi, 2009a; 2009b; 2009c). In order to have compatibility with existing research decided to culture, this research has categorised the cultural issues into 6 groups which were defined by the six dimensions of the cultural issues. The relevant search engines used on the internet mainly cite academic papers for literature review such as Library Catalogue Plus. This is the library online catalogue and individual databases of Loughborough University and other search engines e.g. Google, Google Scholar, and Bing.

- **Phase 2**: The data collection of various ISTE classifications from other researchers was gathered from the literature review. The research method was search engines to collect data from literature in a similar way as the process in phase 1. For example, Library Catalogue Plus of Loughborough University, and other main search engines e.g. Google, Google Scholar, Bing and etc. In addition, some academic papers for literature review were obtained using the inter-library loan system, where they could not be found in the online database system of Loughborough Library.

- **Phase 3**: The data collection for the existing ISTE classifications and the new classification was derived from two kinds of participants namely the PGCE students and the science museum experts. In the case of the PGCE students, the aims and objectives of the research in case study 1 will be explained to the PGCE students in their classroom in about 5 minutes. Then an A3 sized printed poster described the cultural issues relating to ISTE in Appendix 1 and a paper document described the ISTE’s classifications was presented to
these PGCE students. The copies of the poster and the document were put on the tables of each PGCE students’ group for reading in about 15 minutes. The copies of the paper-based questionnaire were assigned to these students for filling in and completing. The assignment of the questionnaire had a time limit of 20 minutes. After that, the feedback from these PGCE students on their paper-based survey was collected. For the experts at the museums, the same paper-based questionnaire was developed into an online survey version. This was attached to an email along with a reference letter from the supervisors. The letter stated the aims and objective of this case study. The email included a paper document describing the existing classifications and the new classification of ISTE provided by the experts based on their understanding. The email had an explanation of how to enter the online survey; it specified an expiry date on the web link for the survey and ensured this acted as a reminder for the experts to complete the online survey. Finally, the feedback from the experts’ online questionnaire was collected from the online system and then it was checked.

Phase 4: The data collection of the cultural issues relating to ISTEs was gathered by interviewing the experts of the museums of science in the UK and the NSM in Thailand. Appointments were made with the experts to visit them at their museums. At this meeting, their museum participants’ answers to the interview questions were discussed. For the NSM in Thailand, this meeting was conducted via an internet system and was recorded for further analysis.

Data analysis of case study 1
Data from the four phases was analysed using different methods such as Likert-scale, cluster analysis, inter-rate reliability, and reliability of qualitative analysis.

Phase 1: The cultural issues relating to ISTE were reviewed by re-examining the MA study of the author, Sumath Awsakulsutthi (Awsakulsutthi, 2009a; 2009b; 2009c) and by considering the output
from the literature review. Then several cultural issues was identified and then categorised in terms of the dimensions of the cultural issues.

- Phase 2: The existing classifications of ISTEs were considered as to whether any could be used to apply to the different cultural dimensions generated in this research. An examination of the existing classifications of ISTEs was made to see if those currently used could be adapted for the 6 dimensions of the cultural issues. Because the existing classifications could not be used, a new classification of ISTEs was developed.

- Phase 3: The new classification of ISTEs was established using cluster analysis for identifying the previous existing ISTE classifications using the criteria in the Likert Scale. Then the new classification was analysed to determine the most important characteristics of ISTEs which can be connected to the cultural dimensions.

- Phase 4: The interview results from the experts relating to the cultural issues and their interaction with ISTEs use were analysed. Those results of the experts which were judged to be reliable were then used to generate an online questionnaire for use by experts worldwide. This was reported in case study 2.

### 3.11.2 Case study 2: The 10 dimensions of the cultural issues

This case study was to evaluate the cultural issues relating to ISTEs. Firstly, the 10 dimensions of the cultural issues were established from two main reviews namely a re-examination of the MA study of the author and other researchers’ materials from the literature review. The validity of these cultural issues relating to ISTEs was observed at the science museums. The online survey provided the author with information about several aspects of the cultural issues from many experts of museums of science from around the world. The outcome of these multiple views from several experts demonstrated whether the 10 dimensions of the cultural issues influenced
their visitors’ learning and understanding of the interactive science and technology exhibits.

**Target population in case study 2**
The participants in case study 2 are selected on the basis of a background of scientific knowledge and/or have a strong association with ISTEs. These participants were taken from several groups of the experts who had worked with museums of science from around the world. For example, the participants in this group were the museum experts who are familiar with the development of ISTEs and/or involved in the design of ISTEs. In addition, the participants from several countries were classified in different regions of the world. These were regions featured in the research activity reported in the output from the literature review.

The experts from science museums were invited to contribute to this case study 2. The output which they generate was evaluated to determine their views on the adequacy of the 10 dimensions description of cultural issues.

The existing classifications and the new classification of ISTEs were surveyed in this group. The questionnaire from case study 1 was piloted in case study 2 in order to determine if this questionnaire was appropriate for use in case study 2. The new classification has already been concluded with the validation of this classification at the museums of science described in case study 1 of the chapter 4.

**Sampling of case study 2**
The samples in this case study 2 were taken from numerous museums of science in all the cultural regions around the world. Several sampling positions were established at locations in the participating museums where the participants were expected to engage in this study. They included the roles/jobs of director, manager, science educator, curator, exhibit manager, exhibit designer and staff volunteer. On the other hand, several directors from these museums of science offered a sample of their experts who were directly involved with ISTEs as a part of this study.
Ball (1990) defined that purposive sampling used knowledgeable people who have a professional role, expertise or experience and in-depth knowledge of particular issues. Hence, a sample of the experts was designated for ‘purposive sampling’ drawn from the experts from the target museums of science. The museum participant in the research was chosen by their management. In addition, Cohen et al. (2011, p.155) pointed out that “Just as there are several types of probability sample, so there are several types of non-probability sample: convenience sample, quota sampling, purposive sampling, dimensional sampling, and snowball sampling”. The non-probability sample will be taken as a particular group which represents itself and it would not represent all of the population (Cohen et al., 2011).

Other personal information of these experts was kept as a record of the survey as follows:

- Name of the museums of science
- Country
- Gender
- Age ranges between less than 20 and over 60 years old
- Telephone number for contact
- Personal email address for contact

For the specification of lower ages than 20 years old, any science museum such as the NSM in Thailand provides for young volunteers who participated with local and international visitors relating to ISTEs. These volunteers were students from any university and most of them were younger than 20 years old.

**Instruments of case study 2**

In this case study, all instruments were applied via internet such as an email, a reference letter, and an online survey. Another instrument was an interview question was used for interview sampling of the experts.

- A case study 2 email was sent to museum experts around the world. The Loughborough University email system, part of the UK academic network, was used for sending material electronically to the experts. If
private email services, such as Hotmail, Google, and Yahoo, were used for communication, these internet/ email systems would be ignored. These email systems have a much higher probability of the case study 2 email ending up in the junk, spam or trash mail boxes. The case study 2 email describes the aims and objectives of the research project which the experts were invited to join. The click link of an online survey was inserted into the detail of the case study 2 email, so the experts could decide to click on the link and complete the online questionnaire.

- A reference letter which was provided by the supervisors was attached to the email. Also the logo of Loughborough University and contact details of the researcher appeared on the reference letter to confirm to the experts the trustworthiness and authenticity of the research.

- An online questionnaire was created using an online survey system. By this means information and photos of ISTEs were inserted.

- Interview questions were prepared for the samples of the experts who responded to the online survey.

**Content of the structure of questionnaires in case study 2**
The questionnaires were divided into three case studies. The questionnaire relating to case study 2 comprises of 3 main sections and used a combination of closed-ended and open-ended questions. The structure of the paper-based and online questionnaire was designed using the same structure as follows.

- Section 1: Contact details such as name, name of the museums of science, country and email address.

- Section 2: Background and general information such as gender, age range, and job title in the museum.

- Section 3: Questions about the dimensions of the cultural issues relating to the ISTEs.
Data collection of case study 2
In case study 2, the data collection gathered within 3 main phases were:

- **Phase 1**: the literature review was used to generate keywords which were used to explore more dimensions of the cultural issues relating to ISTEs, and to gather further material from the literature review for the 6 previous dimensions of the cultural issues generated by case study 1.

- **Phase 2**: the validity of the ISTEs relating to the cultural issues was assessed by observing the visitors’ interactions with ISTEs in science museums.

- **Phase 3**: the internet-based survey which can recruit massive numbers of participants who were experts in their science museums.

Data analysis of case study 2
The gathering of data in case study 2 was derived from the 2 phases of online survey and expert interviews. The data analysis was conducted as follows.

- **Phase 1**: the network analysis using a mind map was applied in order to group and establish the 10 dimensions of cultural issues relating to ISTEs. This process was established from the previous research of MA Science Education and from the literature review.

- **Phase 2**: the validity of the 10 dimensions of cultural issues relating to the ISTEs was evaluated using the experience of the author. Also the 10 dimensions of the cultural issues were generated to develop and design an online survey for phase 3.

- **Phase 3**: the online survey analysis used quantitative methods such as statistical analysis to examine the data which came from the responses of experts around the world.
3.11.3 Case study 3: Language issues and conceptual understanding

Case study 3 established which dimensions of the cultural issues were believed to be important for effective visitors’ interaction in their use of the ISTEIs in the opinions of the experts. One of the museums was selected as the site for the observational activities of the author. The selection was based on the application of the following criteria:

- The availability and use of appropriate ISTEIs.
- Regular visitors from overseas and from other cultures, in number which permitted the research activities to be undertaken.
- Visitor numbers need to be such that sample sizes make significant results possible.
- The museums’ response to the request for their interest, support, and involvement in the research is positive and enthusiastic.
- The location of the museum should be as close to Loughborough University as possible. This will facilitate rapid access and ensure the maximum time is available for observational and experimental activities.

The research components in case study 3 are as follows.

**Target population in case study 3**

The target participants of case study 3 have slightly different characteristics from the other groups in case study 2 and in case study 3. The participants of this group might or might not have had any background of scientific knowledge and also they may be a novice where the learning of science is concerned. On the other hand, it was possible that the participants in this case study might overlap with the target groups in case study 1 and case study 2, because the participants in case study 3 were local visitors and international visitors. These visitors may occasionally have had high educational backgrounds of scientific knowledge such as engineers, science educators and scientists who want to visit the museums.
The participants in case study 3 might strongly associate with ISTEs in museums in the world that they know. These participants were taken from general visitors who had become tourists and visited a target museum of this research.

**Sampling of case study 3**

A sample size in case study 3 was taken as a random sample which the specific properties of this sampling were:

- Any local and international visitor entering the target museum of science.
- Both genders - male and female - who want to be volunteers as participants.
- Any disabled person
- The number from which the sample is to be taken is the number of visitors to the target museum visiting each working day, which may vary from day to day.
- Age ranges of the visitors are typically between less than 20 and over 60 years old, this shall be the age criteria
- Participants of varied educational levels such as primary school, secondary school, college, undergraduate, post graduate, or higher. The participant was requested to provide the information relating to their background.
- Status of employment identified such as working, studying, unemployed and retired.
- Various ethnic groups - to form the basis of a major classification of participants’ cultural differences. The major ethnic groups of human adopted in this research were taken from the literature review.

**Instruments of case study 3**

In this case study, all instruments were used in situ in a science museum.

- A target institution where there was an appropriate museum in Leicestershire was invited to participate in this research project. It has the virtue that it was not far from Loughborough town.
o The main exhibits which were ISTEs were chosen by the target museum. These exhibits are respectively categorised in the three groups of the new classification such as group 2 (Simple interaction with complex understanding), group 3 (Multiple interactions with direct understanding) and group 4 (Multiple interactions with complex understanding).

o The paper-based questionnaire used open-ended questions to collect the cultural issues relating to ISTEs from the visitors.

o Video and recording of observations was used to gather the information/data relating to the visitors’ interaction with ISTEs.

Data collections of case study 3

In case study 3, the data was gathered from three phases of data collections of paper-based surveys, observations, video recording, and a discussion group as follows.

o Phase 1: Data collection of the paper-based survey which was gathered from the feedback of local and international visitors. These visitors will be chosen by a random stratified method.

Cohen et al. (2011, p.154) stated that “Random stratified sampling involves dividing the population into homogenous groups, each group containing subjects with similar characteristics”.

Further, a stratified random sample was organised by two processes. First, the characteristics of the wider population must appear in a sample representative which was chosen as a random selection. Second, the size of each sampling was judged by the determination of the researchers or by the table of the sample size calculation using a statistical method (Cohen et al., 2011).

o Phase 2: Data collection by means of observation and video recording was used to gather the interactions of the local and international visitors with ISTEs and between other visitors.
Data analysis of case study 3

Data analysis used both qualitative and quantitative methods. In case study 3, the three phases of data collection was analysed such as paper-based survey, observation and video recording as follows.

- Phase 1: Data analysis of the paper-based survey which examined the feedback of local and international visitors using statistical methods and qualitative methods. The choice of the two statistical tests was Wilcoxon nonparametric test in case study 3 to consider two experimental conditions, and the Mann Whitney U test to compare different subjects. The qualitative data on the paper-based survey came from the response of participants which were used to categorise in terms of the relation of any dimension of cultural issues, such as language issues and conceptual understanding.

- Phase 2: Data analysis of the observations and video recordings describes the visitors interacting with ISTE.s in terms of the cultural issues. The qualitative data from these two methods were used to group repeating patterns of visitors’ interaction. These groups of interactions were analysed to identify dimensions of the cultural issues. This was prepared in the form of a qualitative report.

3.12 Summary

This chapter describes the research methodology and the reasons for the choice of methods to address the research questions. The research design for this study was planned to increase understanding of the cultural issues relating to interactive science and technology exhibits (ISTEs). The eight research questions were formed to support the research topic as “A study of the importance of cultural factors in the user interaction with, and the design of, interactive science and technology exhibits in museums”. The methods used shall seek to find answers to the eight research questions. The methods comprised quantitative and qualitative research which were used to develop
the three case studies to address the research questions. Each case study focuses on tackling the research questions. Also ethical considerations are an important part of this research. These considerations have been addressed by ethical submission forms which have been submitted to the relevant school and university ethics procedures for their approval.
Chapter 4
Case study 1:
Exploring the cultural issues and classifying interactive science and technology exhibits

4.1 Introduction
This chapter focuses its approach on two main terms:

1. The cultural differences relating to interactive science and technology exhibits (ISTEs) when using the term ‘cultural issues’.
2. A new classification of ISTE is initially formed from an understanding of their relationship. The approach consists of several methods used in a case study. These are network analysis, cluster analysis of new classifications, inter-rater reliability, paper-based questionnaire, and expert interviews.

<table>
<thead>
<tr>
<th>Research questions of the enquiry:</th>
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<tr>
<td>RQ 1</td>
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<td>RQ 2</td>
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<td>RQ 7</td>
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<td>RQ 8</td>
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Table 4.1: Research questions in chapter 4
4.2 Background

From the literature review in chapter 2, the word ‘culture’ (Aasen, 1998; Buchanan, 1998; Hughes, 2005; Rama9art, 2012; Sakamoto, 2003; Tanase, 1959; Tylor, 1871; Walker and Chaplin, 1997), and the term ‘cultural difference’ (Brislin, 1993; Laroche, 2008; Serpell, 1976; Trompenaars and Hampden-Turner, 1997) were defined, including the cultural models from many researchers such as Hall (1959), Hall and Hall (1990), Hofstede (2001), Trompenaars (1993), Trompenaars and Hampden-Turner (1997), and Victor (1992). It was also found that several existing classifications of interactive science exhibits currently in use were identified by many researchers such as Ghose (2000), Gilbert and Stocklmayer (2001), and Sandifer (2003). Boisvert and Slez (1995) and Afonso and Gilbert's (2007) reported the taxonomy in the literature which they had developed, after cluster analysis had been conducted. All of these classifications need to be evaluated as to which is most suitable for investigating the effect of cultural issues on the use of interactive science and technology exhibits (ISTEs).

4.3 Aims and objectives

The overall aim of this study was to identify the cultural issues that may significantly affect the use of interactive science exhibits and to define their relationship. The particular study objectives were:

► To explore cultural issues relating to interactive science and technology exhibits (ISTE) and re-examine them from the previous MA study of the author (Awsakulsutthi, 2009a; 2009b; 2009c).

► To identify the existing classifications of interactive science exhibits in order to research and evaluate their properties which are presently suitable for ISTE (interactive science and technology exhibits) or not?

► To develop a new classification of ISTE with particular reference to the cultural issues and to assess whether the existing classifications of ISTE are appropriate.
To interview the experts at the science museums to receive their ideas about the cultural issues relating to the design and use of ISTEs.

4.4 Methods

Three main phases for using several methods in this study were:

4.4.1 Phase 1: The cultural issues relating to ISTEs

Cultural issues relating to ISTEs were categorised using the network analysis method. The term ‘textual analysis’, - sometimes called ‘text network analysis’ (Gruszecka and Pikusa, 2014) or ‘network analysis of texts’ (Batagelj et al., 2002) - is a kind of network analysis which was described in chapter 3: methodology. Macdonald and Headlam (2009, p.71) referring to ‘textual analysis’ said “It involves working on a text in depth, looking for keywords and concepts and making links between them. The term also extends to literature reviewing”.

Table 4.2 shows the key words used for searching the literature review relating to interactive science and technology exhibits (ISTEs).

<table>
<thead>
<tr>
<th>Culture</th>
<th>Exhibit</th>
<th>Museum</th>
<th>Education</th>
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<tbody>
<tr>
<td>Visual culture</td>
<td>Interactive</td>
<td>Museum study</td>
<td>Science education</td>
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<tr>
<td>Thai culture</td>
<td>Interactive exhibit</td>
<td>Museum learning</td>
<td>Asian culture</td>
</tr>
<tr>
<td>Western culture</td>
<td>Interactive science exhibit</td>
<td>Science museum</td>
<td>Lifelong learning in science</td>
</tr>
<tr>
<td>Science culture</td>
<td>Traveling exhibit</td>
<td>Science centre</td>
<td>Lifelong learning in science education</td>
</tr>
<tr>
<td>Cultural science</td>
<td>Hands on</td>
<td>Science park</td>
<td>Lifelong learning in science and technology</td>
</tr>
<tr>
<td>Science and technology culture</td>
<td>Minds on</td>
<td>Science gallery/galleries</td>
<td>Cultural design</td>
</tr>
<tr>
<td>Interactive culture</td>
<td>Science exhibit</td>
<td>Museum gallery/galleries</td>
<td>Cultural education design</td>
</tr>
<tr>
<td>Interactive science culture</td>
<td>Interactive exhibit taxonomy</td>
<td>Science and technology centre</td>
<td>Cultural interactive exhibit</td>
</tr>
<tr>
<td>Interactive exhibit culture</td>
<td>Interactive exhibit classification</td>
<td>Visitor experience</td>
<td>Cultural interactive exhibit design</td>
</tr>
</tbody>
</table>

*Table 4.2: Key words used for literature search relating to ISTEs*
4.4.2 Phase 2: The existing classifications of ISTEs

The two key questions are:

► Why should the interactive science and technology exhibits be developed into a new classification?

Any new classification should eventually enable greater analysis of the educational purposes and effectiveness of different kinds of interaction in ISTEs. This may lead to the development of guidelines for the inclusive design of interactive science exhibits.

► How can the existing classification be re-classified?

Classifying interactive exhibits from several researchers in the literature review in Chapter 2 suggests four main existing classifications of interactive science exhibits. The existing classifications of interactive science exhibits - e.g. Ghose (2000), Gilbert and Stocklmayer (2001), and Sandifer (2003) - will be identified. If any of these classifications are not appropriate, a new classification will be constructed using the research methods in phase 3.

4.4.3 Phase 3: New classification of ISTEs

Examples of 56 interactive science and technology exhibits (ISTEs) were drawn from the exhibits of the NSM, Thailand. A new classification of ISTEs was established based on knowledge of those who created interactive science and technology exhibits' classification. The new classification of ISTEs was developed using four methods - criteria for Likert scale, inter-rater reliability, cluster analysis, and questionnaire - as follows.

1. Criteria for Likert scale

Before a new classification was established, the methods of researchers in the literature review such as Ghose’s (2000), Gilbert and Stocklmayer’s (2001) and Sandifer’s (2003) were investigated. Then a suitable classification of the interactive science and technology exhibits (ISTEs) at the NSM in Thailand was carried out. One way of tackling this issue used a Likert Scale
for each characteristic. An appropriate scale is shown in the following table which has a 7-point response. This scale is the criteria for rating each ISTE.

| Criteria for rating each interactive science and technology exhibits (ISTEs) for each of the characteristics |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Not present | Very slightly present | Slightly present | Average presence | Strongly present | Always present | Crucially present |

Table 4.3: Shows 7-point response scales
[Adapted the 7-point response scales from Vagias (2006)]

2. Inter-rater reliability
The SPSS software applied to the data formed it into clusters; then the author interpreted the clusters using Inter-rater reliability. The 11 characteristics of the 56 interactive science exhibits were classified. 1-4 come from the original ideas of Ghose (2000), 5-7 from Gilbert and Stocklmayer (2001), and 8-11 were suggested by Sandifer (2003). These are:

- Two-way communication
- Multiplicity
- Discovery process
- Simulated situation
- A simple demonstration of a phenomenon
- Matching both a real-world phenomenon and the consensus model
- A ‘far’ analogy to represent the consensus model
- Technologically novel
- Open-ended
- User-centred
- Stimulates the senses

Appendix 2 shows rankings by the author of all the 56 interactive science and technology exhibits (ISTEs) of the NSM according to these criteria. These rankings were based on his experience as a science educator and interactive science exhibit developer of the NSM. The ratings given need to be verified by other experts to check inter-rater reliability. The inter-rater reliability was explored by including a sample of the expert’s ranking in the questionnaire.
3. Cluster analysis
The data generated from the Likert 7-point response scales of the 56 ISTEIs of the NSM was analysed using the ‘cluster analysis’ package on the SPSS software.

4. Paper-based questionnaire
The questionnaires were designed into two versions of a paper-based and an online survey. First, the paper-based questionnaire was developed as a pilot version for five PhD colleagues at LDS before it was launched as a paper-based version. Secondly, the UK feedback started from 16 PGCE students. The pilot questionnaires were distributed to these students in the classroom with the classifications of interactive science exhibits paper. The students first read this paper then they provided the feedback. These questionnaires were finished within 2 hours. Third, the paper-based questionnaire was improved and modified into an online version for the experts at the NSM in Thailand.

This feedback has 4 main components:

- Research strategy
- Previous categorisation strategies
- New categorisation method
- Cultural issues

However, there are sub questions in each main question as specific details such as Yes/No and explanations. This questionnaire was printed on A4 papers and attached to an A3 poster describing cultural issues learning through the use of interactive science exhibits. However, the A3 poster was resized as an A4 poster (See Appendix 1).

5. Online questionnaire
International feedback was developed from the paper-based questionnaire used by the PGCE students. There were three versions of development of these questionnaires which were used on the online survey. They were sent to the NSM colleagues in Thailand. In addition, the NSM colleagues were asked to read the taxonomies of interactive science exhibits in order to prepare themselves for the online survey.
• This first online version had 22 questions applied using the Bristol Online Surveys’ system (BOS), and inserted a small poster of A4 size of relating to cultural issues learning through the use of interactive science exhibits.

• The second version had 23 questions. The main questions were separated into two parts. These were modified and moved the cultural issues of interactive science exhibits into the first part and the taxonomies of the interactive science exhibits into the second part. This version also removed the A4 poster, replacing it with the questions relating to the cultural issues. The main reason for changing this online survey is the more readable details of an A3 poster – this was to tempt the respondents to spend their time reading other details in the A3 poster - such as a background of the research and a definition of culture.

• Finally, the third version had 23 questions. A new question was inserted between questions 21 and 22 relating to a new classification of ISTE. The complete online survey was presented with 23 questions (See in Appendix 3). The online questionnaire was sent to the NSM colleagues in Thailand. These included a science exhibit consultant at the Science Museum, a physics educator at the Information Technology Museum, the director of the Natural History Museum and a science laboratory consultant who is Japanese.

4.4.4 Phase 4: The experts’ interview for the further cultural issues
The experts’ interview provided their ideas about the cultural issues which they believe were relevant to the design and use of ISTE. Two research interviews were conducted. Initially, there were interviews with a UK expert and then an international museum expert, the NSM in Thailand. The 10 questions prepared for these interviewees were as follows.
Q1: What is your name?

Q2: May I know how old are you?

Q3: What is your position at the museum?

Q4: How long have you worked at the museum?

Q5: How many visitors visit this museum per year?

Q6: Do you believe that the cultural issues affect the visitors learning through the interactive science exhibit or not? For example, physical skills, technologies issues, language issues, visual cultures, conceptual understanding and social issues. Why do you think like that?

Q7: Do you believe that the cultural issue are influenced by gender when interacting with interactive exhibits or not? Why do you believe like that?

Q8: What are the characteristics of the interactive exhibits which build on cultural differences and affect learning?

Q9: What are other factors such as age, gender, and educational level, which significantly relate to cultural differences for learning interactive exhibits?

Q10: How can interactive exhibits be developed to avoid the adverse effects of cultural differences?

4.5 Results

4.5.1 Phase 1: The cultural issues relating to ISTEs

Initially, the literature review of cultural issues conducted by Awsakulsutthi (2009a; 2009b; 2009c) was re-examined from the perspective of cultural issues. Six categories of cultural differences were identified by comparing European and Thai behaviour using network analysis of texts and a mind mapping visualisation by the author. Several examples of interactive science
exhibits were selected from the NSM, Thailand and connections made to them by the six categories - e.g. physical skills, technologies issues, language issues, visual cultures, conceptual understanding, and social issues. These categories of cultural differences were called the dimensions of the cultural issues relating to ISTEs. This is illustrated in the following table:

<table>
<thead>
<tr>
<th>Cultural issues</th>
<th>European</th>
<th>Thailand</th>
<th>Examples of NSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical skills</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Western person using a knife cuts towards themselves ( Awsakulsutthi, 2009c). |          | Thai person using a knife cuts away from themselves ( Awsakulsutthi, 2009c). | ‘Human Power’ exhibit’
| Technologies issues |          |          |                |
| Light switches in the European countries are designed to operate in the opposite direction for turning on and off to those in the USA (Frater, 2007). |          | Press down on most electricity switches | ‘Electricity from the sun’ exhibit’
| Press down on most electricity switches |          |          | The visitors may press the buttons in |
Scientific words could be interpreted to have different meanings in various cultures. For example, it was discovered that the word ‘impurities’ may be misunderstood by international postgraduate students (Awsakulsutthi, 2009a).

Most scientific words are new for Thai people. The exhibits need to provide a meaning of the words. For example, - Gravity - Fluidised bed - Optical fibres.

Thai visitors may misunderstand the definition of plasma which originated as a scientific word in Western vocabulary.

This example of concept cartoons illustrates a scientific idea. Its construction reflects the Western lifestyle (Awsakulsutthi, 2009a).

Thai proverbs illustrate traditional visual cultures e.g. relationship, life, and fortune (Thai Smile, 2011).

An example is ‘The frog in a coconut shell’ means a person living in a small area. But the person is proud as they are the owner of knowledge in the coconut shell (Werner, 2011).

It shows diagrams of the vocal cords working.

Some of the visitors may not understand the diagrams showing the way of the vocal cord exhibits works, where were created in Western style.
Conceptual understanding

Children have many ideas about light and vision. Most Western children had a misconception about light that it goes from eyes to the objects (Awsakulsutthi, 2009b). This misconception was influenced by the comics and fairy tales (Ramadas and Driver, 1989).

For example, heat vision emitted by Superman's eyes is like twin red laser beams (Beatty, 2006).

Social issues

European people greet each other by shaking hands (Awsakulsutthi, 2009c).

Thai people respect other people by 'Wai' (Awsakulsutthi, 2009c).

The visitors may not understand the refraction of light and visual image of a female doll in Thai costume.

The visitors need to interact by mimicking the action of shaking-hands with the Real Image exhibit. However, most Thai people know 'Wai' rather than shaking-hands.

Table 4.4: Identification for the six dimensions of cultural issues relating to ISTE

[Illustrated by the author]
4.5.2 Phase 2: The existing classifications of ISTEs
Before efforts were made to establish a new classification, it was important to consider whether or not any of the classifications developed by these three references - Ghose (2000), Gilbert and Stocklmayer (2001), and Sandifer (2003) - were appropriate for more general application. This exploration was made in relation to the examples from the 56 interactive science and technology exhibits at the NSM in Thailand. The difficulty of placing these exhibits in unique categories would have led to later difficulties in the experimental design and this fact is described in Appendix 4.

4.5.3 Phase 3: New classification of ISTEs
Two main results in this phase are:
1) The groups are formed by the cluster analysis
2) New classification of interactive science and technology exhibits 
   (ISTEs) is shown in Figure 4.1 after the processes of ‘criteria for Likert scale’, ‘inter-rater reliability’, and ‘cluster analysis’ were completed.

1. The groups are formed by the cluster analysis
The cluster analysis was conducted and it generated the four groups of interactive science and technology exhibits (ISTEs) which were then ranked. This classification derived from Sandifer’s (2003) approach because the other researchers’ approaches are not evident. These researchers were Ghose (2000), Gilbert and Stockmayer (2001). They were not able to provide an analysis of interactive science exhibits using the definitions described below to place every exhibit into one of the classifications. Further elaboration is provided in Appendix 5.
Figure 4.1: The groups are formed using cluster analysis

[A new classification derived from Sandifer’s (2003) approach which was based on ranking by the author].
2. New classification of interactive science and technology exhibits (ISTEs)

The new classification of interactive science exhibits, including ISTEs, which was created is shown in the following diagram. It consists of four groups:

![Diagram of new classification of ISTEs]

The description of the four new groups is:

**Group 1: Simple interaction with direct understanding**

Any exhibit is a member of this group, if the exhibit fulfills the following four criteria:

- Most of the exhibits in this group can interact with one visitor per one exhibit. Other visitors can observe and listen to the exhibit but they may not interact with it directly. Also they can understand how to control it easily from observing the visitor who is still interacting with the exhibit.
When the visitors use one or more of their senses such as seeing, hearing, smelling, tasting to interact with the exhibit, they can understand how to interact with it directly and understand the information that the exhibit is communicating to them. For example, the exhibit makes a movement or flashes lights and the visitors can interpret that exhibit's output and understand what the exhibit presents to them directly.

The visitor can interact with the exhibit by only one hand/finger. To control the exhibit they use movements such as bending, clicking, grabbing, hitting, lifting, moving, plugging, pressing, pulling, pumping, pushing, rolling, rotating, shaking, sliding, spinning, swinging, stirring, throwing, touching, and waving.

The exhibit offers an opportunity for visitor(s) to discover the answers to questions directly in a simple way. For instance, the exhibit shows the results of each numerical digit which are equal to the number of the images of animals appearing on a monitor display. The visitor(s) can understand the exhibit directly when they can see the result clearly e.g. they can compare the images of the animals to the numerical digits in this exhibit, and they correspond exactly.

Two examples are derived from the 14 exhibits in this group as follows.

First example, the 'Bulbs and batteries' exhibit at the NSM in Thailand (See no. 17 in Appendix 6) is classified in group 1 by satisfying the following criteria.
Figure 4.3: ‘Bulbs and batteries’ exhibit

- The exhibit can interact with one visitor. In addition, many visitors may join to participate in its use together.

- The visitor uses three senses in this exhibit such as interacting by touch, using a hand, seeing with the eyes, and listening with the ears. When the visitor connects the circuit board completely and presses the button, they can see the bulbs lit and hear the sound from the loud speaker.

- The visitor can interact with the exhibit using one hand.

- The visitor can understand how to interact with the exhibit and what the output from the exhibit means.

Second example, the ‘Wind power’ exhibit at the NSM in Thailand (See no. 49 in Appendix 6) is categorised in group 1 by satisfying the following criteria.

Figure 4.4: ‘Wind power’ exhibit

- The exhibit can interact with one visitor.
The exhibit has models of a windmill and a wind turbine. The wind is produced from an air channel. Both models can be activated and rotated by wind after pressing a button. The visitor is led to understand how these wind models work and that they are not-open ended.

- The visitor can interact with the exhibit by one finger pressing a button.

- The visitor can understand the different power outputs between the models of the traditional windmill and the modern wind turbine. Both models obtain the same wind power from the wind channel. The visitor can observe both bright lights at the front of the exhibit.

**Group 2: Simple interaction with complex understanding**

Any exhibit can become a member of this group, if it meets the following four criteria:

- Most of the exhibits in this group can interact with one or more visitors per one exhibit.

- The visitors can interact with the movement of the exhibit by the use of only one hand/finger and control the exhibit using actions such as bending, clicking, grabbing, hitting, lifting, moving, plugging, pressing, pulling, pumping, pushing, rolling, rotating, shaking, sliding, spinning, swinging, stirring, throwing, touching, and waving.

- Using some parts of the body or using voice visitors can interact with this exhibit - such as stepping on, biking, and sitting on, showing hands or body movement. This interaction stimulates more senses so it provides a more complex task to understand how it works, and what information the exhibit may present to the visitor.

- The concept of this exhibit is to transfer the scientific knowledge to the visitor through thoughtful operation, what visitors are thinking.
about doing with the exhibit. For example, when the visitor(s) rub any objects on cloth, they can see and compare which object is capable of creating and sustaining an electrostatic charge.

Illustrations of these points are seen in two examples derived from the 13 exhibits in this group, as follows.

First example, the ‘Magnetic forces – attraction and repulsion’ exhibited at the NSM in Thailand (See no.12 in Appendix 6) was classified in group 2 by satisfying the following criteria.

![Figure 4.5: ‘Magnetic forces – attraction and repulsion’ exhibit](image)

- The exhibit can interact with one or more than one visitor. Up to four visitors can interact with the exhibit, each one with one of the four magnets.
- The visitor(s) can use one hand to grab each of the four magnets.
- The visitor uses one hand as the part of the body to interact with the magnets in the exhibit.
- The visitor needs to compare the results with the varying magnetic forces and discover how the magnetic forces have no effect on other materials.
Second example, the ‘Addition – how fast are you?’ exhibited at the NSM in Thailand (See no. 28 in Appendix 6) was categorised in group 2 because it meets all the following criteria.

Addition exhibit can interact with one or more visitors. Two visitors or more than two visitors can interact with a calculator and an abacus together at the same time.

The visitor can use one hand to press any button of the calculator and to slide any bead of the abacus.

The visitors can use only one part of their body - their hand - to interact with the abacus or the calculator.

The visitors need to compare the results from using the calculator and the abacus. They also need to know how the calculator and abacus work.

**Group 3: Multiple interactions with direct understanding**

Any exhibit may be a member of this group, if it meets the following four criteria:

- Most of the exhibits in this group can provide interaction with more than one visitor per single exhibit.

- When the visitors use one or more of their senses such as seeing, hearing, smelling, tasting and interacting with the exhibit, they can...
understand how to interact with it directly and what to do. For example, the exhibit shows a movement or flashes lights and the visitors can interpret the idea and understand what the exhibit presents to them directly.

- To control the exhibit, the visitors need to use one or two hands or feet and/or both hands and feet. They can then execute bending, clicking, grabbing, hitting, jumping, lifting, moving, plugging, pressing, pulling, pumping, pushing, rolling, rotating, shaking, sliding, spinning, swinging, stepping, stirring, throwing, touching, and waving. For example, both hands of the visitor manipulate the exhibit in different ways so one hand pushes a button and another hand rotates a disc.

- The concept of this exhibit is to transfer scientific knowledge by giving results or answers to visitors’ questions for direct understanding. For example, the visitor can compare the sensation of heat by touching three different hot materials.

Two examples are as follows:

First example, the ‘Newton and the apple’ exhibited at the NSM in Thailand (See no. 3 in Appendix 6) was classified in group 3 as it meets the following criteria.

![Figure 4.7: ‘Newton and the apple’ exhibit](image-url)
The exhibit can interact with one or more than one visitor. Many visitors can help one another to lift up the four balls of different weights up. Another visitor not doing any lifting can wait and press the button on the right hand side, at the appropriate movement.

The visitor can use their hands to raise up these four heavy balls.

The visitor can understand the results easily - the falling of the balls to the floor. They can see the time taken for the balls to fall to the ground is the same in every case. This is a clear presentation of the existence of gravity, and of the power of gravity.

The visitor can see and compare the four balls of different weights by handling them. After the visitor pushes the button, they can observe each ball coming down in the same time.

Second example, the ‘Speaking tubes’ exhibit at the NSM in Thailand (See no.42 in Appendix 6) is categorised in group 3 as it meets the following criteria.

![Image of 'Speaking tubes' exhibit]

The exhibit can interact with one or more than one visitor. Four visitors can interact with these four types of the ‘Speaking tubes’ exhibit together at the same time.

The visitors can use their voice to speak and their ear to listen to the sound of their voice as it comes back to them.
The visitors can understand the purpose of the speaking tubes and how the sounds coming to them have different frequencies which are directly related to the sizes of the tubes.

The visitors can compare the different sounds from the Speaking tubes exhibit.

**Group 4: Multiple interactions with complex understanding**

Any exhibit may be a member of this group, if it meets the following four criteria:

- Most of the exhibits in this group can interact with more than one visitor per one exhibit.

- To control the exhibit, the visitors can use one or two hands or two feet or both hands and feet. They can then execute bending, clicking a mouse button, grabbing, hitting, lifting, jumping, moving, plugging, pressing, pulling, pumping, pushing, rolling, rotating, shaking, sliding, spinning, swinging, stepping, stirring, throwing, touching, and waving. For example, both hands of the visitor can manipulate the exhibits in different ways such as one hand pushes the button and another hand rotates the disc.

- Using some parts of the body or the body or voice or hearing enables interaction with this exhibit such as stepping on, speaking, biking on, sitting on, showing hands or body movement.

- The concept of this exhibit, which is complex, can be communicated to the visitors, but they cannot understand clearly how to interact with it easily; nor exactly what its purpose is. For example, the visitors need to compare the different intensities and patterns of light emitted using many types of lens.

Two examples are derived from the 16 exhibits in this group as follows.
First example, the ‘Plasma ball’ exhibited at the NSM in Thailand (See no. 23 in Appendix 6) was classified in group four as it meets the following criteria:

- The ‘Plasma ball’ exhibit can interact with more than one visitor.
- The visitors can use one or two hands to touch the surface of the plasma ball.
- The visitor uses their hands as the part of the body to use to interact with the plasma ball.
- The ‘Plasma ball’ exhibit presents an object with complex scientific knowledge which are hard to be understood. The visitors need to know what plasma means and this is not general scientific knowledge.

Second example, the ‘Real image’ exhibited at the NSM in Thailand (See 52 in Appendix 6) which was categorised in group four as it meets the following criteria.
The Real image exhibit can interact with more than one visitor. This is because one visitor can put his/her hands into the black shiny bowl and other visitors can also put their hands inside it at the same time.

The visitors can put one or two hands in the bowl.

The visitors need to use their hands to interact with it, but some visitors try to use other parts of body such as their heads.

The Real image exhibit requires complex understanding because the visitors need to know what ‘Real image’ means, how it works, and how to interact with it.

3. Feedback questionnaire
Two main feedback questionnaires were examined as follows.

Feedback from the PGCE students
On the paper-based versions of the questionnaires, eight PGCE students (half of them) did not write their names on the questionnaire, so their results remained anonymous. Comments were distilled from significant ideas the PGCE students put forward. The following is a compilation of these comments.

- There is too much information to read in the taxonomies of interactive science exhibits paper.

- They prefer to see the video clips of the interactive exhibits and present them in the classroom. They cannot understand how the visitors would interact with the real exhibits.

- The PGCE students suggested experimenting with or developing the real exhibit and actually testing them with visitors rather than using a questionnaire.

- The 7-point response scales are suitable for ranking the characteristics of interactive science exhibits.

- The exhibits should have more information and explanation provided in their description. For example, the visitors could do more than just
watch the crystals exhibit, but needed more information suggesting other things to do with the exhibit and why.

- Half of the PGCE students believed that the cultural issues did affect visitors’ learning to use the interactive science exhibits. The others did not respond to the question dealing with these cultural issues.

- **Feedback from the expert at the NSM in Thailand was:**
  - He agreed with the choice of criteria and scale descriptors.
  - He believed that the four groups in the new classification can be useful.
  - He argued that Ghose’s (2000) classification is most useful and closer to real life.
  - The following table compares the exhibit ranking in the Likert scale of the author (in each white row) and the NSM expert (in each grey row).

<table>
<thead>
<tr>
<th>Interactive Science and Technology Exhibits (ISTEs)</th>
<th>Marker</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8 9 10 11</td>
</tr>
<tr>
<td>1 Magnetic forces – attraction and repulsion (See 12)</td>
<td>The author</td>
<td>7 7 4 5 6 6 5 5 5 1 1</td>
</tr>
<tr>
<td></td>
<td>NSM expert</td>
<td>5 5 5 5 5 4 4 4 5 5</td>
</tr>
<tr>
<td>2 Gravity and plants (See 2)</td>
<td>The author</td>
<td>7 7 5 5 6 6 4 5 6 1 6</td>
</tr>
<tr>
<td></td>
<td>NSM expert</td>
<td>5 5 5 5 4 5 5 5 4 4</td>
</tr>
<tr>
<td>3 Useful friction (See 11)</td>
<td>The author</td>
<td>7 7 5 6 7 6 5 4 5 6 1</td>
</tr>
<tr>
<td></td>
<td>NSM expert</td>
<td>4 4 4 5 5 4 4 4 4 3</td>
</tr>
<tr>
<td>4 Real Image (See 52)</td>
<td>The author</td>
<td>7 7 6 7 6 2 6 3 7 7 6</td>
</tr>
<tr>
<td></td>
<td>NSM expert</td>
<td>3 3 4 3 3 3 4 3 4 3</td>
</tr>
</tbody>
</table>

Table 4.5: The 4 examples of exhibit ranking

[Abbreviations e.g. ‘See 12’ means ‘See exhibit 12 in Appendix 6’]

**7-point response scales:**

Not present = 1  Very slightly present = 2  Slightly present = 3  Average presence = 4  Strongly present = 5  Always present = 6  Crucially present = 7
4.5.4 Phase 4: The experts’ interview for the further cultural issues

The results of the experts’ interview at the Snibston Discovery Museum in the UK and the the NSM in Thailand were compared and contrasted in Appendix 7.

4.6 Discussions

4.6.1 Phase 1: The cultural issues relating to ISTEs

The cultural differences relating to ISTEs were explored in the work on science education originally done by Awsakulsutthi (2009a, 2009b, 2009c), with the definitions of cultures in the literature review and these were connected to the examples of exhibits in the NSM, Thailand. Six dimensions of the cultural issues were found - physical skills, technologies issues, language issues, visual cultures, conceptual understanding, and social issues. For example, the children’s conceptual understanding of vision was one where something goes from their eyes to the object book (Ramadas and Driver, 1989). Therefore they misunderstand the symbolic significance between the arrows of light rays and arrows from the eyes going to the objects. This is because children have limited pre-information in the understanding of light direction and visual perception. Further, at Piaget’s ‘concrete operational’ level (typically before 12 years old) (Zanker, 2000), the object is seen because they believe that light goes to the object from the eyes. At an older age at the ‘formal operational’ level, the object is seen and the children understand, or have been taught, that light goes to the eyes from the object. Cultural differences in teaching, about the phenomena of light and vision e.g. Kaewkhong et al. (2010) who studied children’s ideas of refraction in the classrooms of Thailand may influence this transition in children’s understanding as they get older. This may also cause Thai children’s
cognition to have a misconception of what refraction is when they learn, through using ISTEs at the museums of science.

4.6.2 Phase 2: The existing classifications of ISTEs
The existing classifications Ghose (2000), Gilbert and Stocklmayer (2001), and Sandifer (2003) do not provide for the appropriate classification of the examples of ISTEs at the NSM as shown in Appendix 4. It was concluded that a new classification of ISTEs was required and this should be developed in phase 3. Further, Afonso and Gilbert’s (2007) classification uses two terms - (1) Exhibits as exemplars of a phenomena, and (2) Analogy-based exhibits. By comparison, Gilbert and Stocklmayer’s (2001) classification uses the three terms - (1) A simple demonstration of a phenomenon, (2) Matching both a real-world phenomenon and the consensus model, and (3) A ‘far’ analogy to represent the consensus model. This suggests that the definitions of Afonso and Gilbert’s (2007) classification do not consider the term (2) ‘Matching both a real-world phenomenon and the consensus model’ - of Gilbert and Stocklmayer’s (2001) classification. For this reason, Afonso and Gilbert’s (2007) classification was not used in phase 3.

4.6.3 Phase 3: New classification of ISTEs
The new classification of ISTEs was successfully used to classify 56 interactive science and technology exhibits (ISTEs) of the NSM, Thailand in four main groups - in Appendix 6. Also this classification provided two main terms - interaction and understanding - which are different from the other previous researchers (Ghose (2000), Gilbert and Stocklmayer (2001), and Sandifer (2003)).

The feedback of paper-based questionnaires from PGCE students proved useful in developing the paper-based survey into the online version. The feedback on the trial online version, from the expert at the NSM in Thailand, was to remove the questions about the classifications of ISTEs for the further online questionnaires. This was because many examples of ISTEs from the NSM may not familiar to those experts who have not seen these ISTEs before. It would be too difficult for those experts to rank each characteristic for these ISTEs.
4.6.4 Phase 4: The experts’ interview for the further cultural issues

The main results of the interviews in Appendix 7 of the UK expert and the NSM expert were shared and reported, as the cultural issues discussed in their interviews, as follows.

The first expert was the Head of Learning at the Snibston Discovery Museum in the UK, and the material generated in his interview can be summarised and categorised using the four dimensions of the cultural issues as follows.

- **Technology issues** – “Some cultures may value technology more which could mean visitors are in general more likely to engage with technology based exhibits” which are similar to Sato and Chen’s (2008) observation in their report that technology using mobile phones can change the lifestyles of its users.

- **Language issues** – “…visitors who use writing systems that read from right to left instead of the Western tradition of left to right” which were found in Schaefer’s (2011) report of the various written styles e.g. Chinese, Japanese, Korean, English, and Hebrew language.

- **Social issues** – “…the accepted social behaviour that is acceptable in a public space…I think a key to developing any interactive is that the message that an interactive seeks to convey needs to be conceptually simple”, which is similar to Watson et al.’s (2002) report of children’s activities with interactive science exhibits.

- **Gender issues** – “This can be seen very easily if you visit toy shops where there are still toys designed and sold for boys and others for girls. I assume that there may be similar distinctions in other cultures” which are similar to Brislin’s (1993) report of gender differences found in all cultures.

The second expert was the Science Show and Exhibit Design Consultant working at the NSM in Thailand. His interview can be categorised into 5 dimensions of cultural issues as follows.
Technologies issues – “Interactive exhibits that use highly technical examples have a poorer chance of connecting with some cultures” which appears in some exhibit as Hornecker and Buur’s (2006) examples of the abacus exhibit with digital devices.

Language issues – “Language plays a major part with an absence of words for technologies. The meaning of flexibility and elasticity in Thai to the general public is not quite accurate for a material”. These words are the same comments as Hofstede’s (2001) reported - that any vocabulary in one language may be difficult to translate into an exact meaning in another language.

Visual cultures – “… atoms and molecules can be very difficult multiculturally as the designer has no idea as to the mental picture conceived by different cultures”. This mention is similar to the viewpoints of Weinschenk (2011) and Schaefer (2011) about the meaning of colour in different cultures. On the other hand, the second interviewee has wider views of people living in different cultures where they may have difficulty in imagining atoms and molecules in their visual images.

Conceptual understanding – “Scientifically, it means a tested answer to a scientific question but one that is still open for other scientists to research to disprove or modify”. This statement is a dissimilar meaning to ‘Conceptual understanding’ meaning ‘conceptual as based on abstract ideas being’ synthesised from Compact Oxford Dictionary & Thesaurus (2009a), and Longman Dictionary of Contemporary English (2003a). On the other hand, the second interviewee believed that the conceptual understanding of any scientific concept can be updated or improved by other experts.

Gender issues – generally young people do not associate science with everyday life, and girls less so than boys” which is similar to Inkpen et al.’s (1994) report of different playing patterns between boys and girls.
“...men and women from the same culture react differently when observing the same activity caused by gender difference”.

The second interviewee commented that “Even the designer can have difficulty in receiving instructions about other cultures. If a multicultural exhibit is to be designed a multicultural team should do it”. His statement provided a wider perspective in terms of ‘multicultural exhibits’ and connected the idea of Macdonald (2007) who expected that many museums, including exhibit designers improve their exhibits by sharing research with other museums to the idea of Marcus (2006) who referred to various cultures with interaction designs.

The recommendations of these two experts support several issues in the interview questions. For example, the gender issues will add a new dimension to the cultural issues in the six dimensions of the next chapter of case study 2.

4.7 Summary

4.7.1 This chapter considers the research question - ‘How to define the relation between the cultural differences and interactive science and technology exhibits, and what categories of cultural differences are there?’ – this was explained in case study 1. Initially, the six dimensions of cultural issues relating to ISTEIs have been explored after identifying the literature relating to:

- Physical skills
- Technologies issues
- Language issues
- Visual cultures
- Conceptual understanding
- Social issues
4.7.2 The new classification system of interactive science exhibits and also ISTE s should be comprised of the four main groups as follows:

- **Group 1:** Simple interaction with direct understanding;
- **Group 2:** Simple interaction with complex understanding;
- **Group 3:** Multiple interactions with direct understanding;
- **Group 4:** Multiple interactions with complex understanding.
Chapter 5
Case study 2:
The 10 dimensions of the cultural issues

5.1 Introduction
Chapter 5 reports a study of the cultural issues. The study involves the use of three methods - network analysis, online questionnaire, and a validation process at the science museums. Network analysis used keywords for searching and mind mapping as tools for classifying the dimensions of cultural issues relating to ISTE. Several stages of development of the online questionnaire were carried out - searching websites, collecting emails from the expert contact list, sending them the online survey, and evaluating the data generated. The validation at the science museums was carried out using direct observations.

<table>
<thead>
<tr>
<th>Research questions of the enquiry:</th>
<th></th>
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<tbody>
<tr>
<td>RQ 1</td>
<td>What is culture, and what is the meaning of cultural differences?</td>
</tr>
<tr>
<td>RQ 2</td>
<td>What is meant by interaction, and what is an interactive science and technology exhibit?</td>
</tr>
<tr>
<td>RQ 3</td>
<td>Why is the classification of interactive science and technology exhibits so important for today and the future; and what classifications are there?</td>
</tr>
<tr>
<td>RQ 4</td>
<td>How to define the relation between the cultural differences and interactive science and technology exhibits, and what categories of cultural differences are there?</td>
</tr>
<tr>
<td>RQ 5</td>
<td>What interest have the experts of the museums of science in culture influencing the use of interactive science and technology exhibits; and which cultural issues do they believe are the most important?</td>
</tr>
<tr>
<td>RQ 6</td>
<td>How do the characteristics of the interactive science and technology exhibit take account of cultural differences which affect learning?</td>
</tr>
<tr>
<td>RQ 7</td>
<td>What are other factors which significantly contribute to cultural differences in learning to use and using interactive science and technology exhibits? For example, age, gender, and educational levels. Why are these factors related?</td>
</tr>
<tr>
<td>RQ 8</td>
<td>How can interactive science and technology exhibits be developed to capitalise more successfully on cultural differences?</td>
</tr>
</tbody>
</table>

Table 5.1: Research questions in chapter 5
5.2 Background

In the literature review, culture is perceived as dynamic and can be transferred (Precious, 2010) and this is connected to the terms ‘immigration’, ‘tourism’, ‘globalisation’, and ‘virtual exhibits’. The UK Association for Science and Discovery Centres cooperates with many science institutes (ASDC, 2014b), hygiene provided for tourists by the exhibits (EmmS, 2002), immigrants’ employability in several countries (Doudeijns and Dumont, 2003), and popular virtual exhibits in museums (Eberbach and Crowley, 2005). In addition, the future of the world needs to increasingly relate to the young generation educated by science, technology and innovation (UNESCO, 2013) and science museums in the world have been increasing in numbers for several years (ASTC, 2009; 2014). For the reasons described previously in 2.7.2 (Out of school settings for learning science), these museums are changing in the light of globalisation and the organisation of their public educational role. Also these museums can be accessed by international as well as local visitors, and these visitors have diverse cultural backgrounds. Furthermore, ISTEs at museums have been occasionally imported - being bought or rented from other countries and installed in their museums as temporary exhibitions or permanent exhibitions. Although the features and functions of such imported ISTEs may present a challenge to local visitors, they may be viewed as new objects for the local visitors to understand and use within the limited visiting times available.

From case study 1 in Chapter 4, the six dimensions of cultural issues relating to ISTEs were generated by a re-examination of the previous MA study (Awsakulsutthi, 2009a; 2009b; 2009c) such as (1) physical skills, (2) technologies issues, (3) language issues, (4) visual issues, (5) conceptual understanding, and (6) social issues. This case study 2 will use a network analysis method to identify other dimensions of the cultural issues.
5.3 Aims and objectives

The overall aim of this study was to find out:

► what cultural issues are perceived as important by relevant staff in the museums.

► designs of interactive science exhibits which would prove to be suitable for local visitors and international visitors from different parts of the world.

The particular study objectives were to investigate:

► relevant organisations - namely - the museums such as aquariums, discovery centres, discovery science centres, planetariums, science museums, science centres, space centres and other specialist museums which have been involved with ISTEs in many countries.

► the opinions of the various expert staff in these organisations such as director, curator, science educator, exhibit designer, volunteer, etc., including a range of ages and countries who participated in this research.

► the comprehension the visitor experiences using of the cultural issues influencing interactive science exhibits as expressed by the several kinds of experts co-operating in this research.

► the relative ranks of the cultural issues voted by the many expert museum staff.

► the most important dimensions of cultural issues relating to the use of ISTEs.

► the overall attitudes of many experts from the museums to different cultures and their influence on visitor behaviour and perceptions.
5.4 Methods

There were three main phases using the various methods in case study 2 described in the Methods chapter. These were:

5.4.1 Phase 1: Finding further dimensions of the cultural issues

First, other dimensions of cultural issues emerged from the literature review. Possible titles of books, journal and conference papers and dissertations were identified using keywords and several search engines (they are shown in Table 1.1 and 1.2 in Chapter 1) – e.g. ‘Library Catalogue’ and ‘Library Catalogue Plus’ of Loughborough University, Google, Google Scholar, and Bing.

A particular choice of methodology in this study was that the questionnaire was developed using an online survey. There were two main reasons for using the online survey, and these were:

- The online survey could gather various opinions from the relevant staff in the many museums (such as science museum, discovery museum, space museum and science centres) in the world which have experts that could read and reply to the email in English.

- It was very convenient for the collection of the massive quantities of information generated. It was easier and quicker to read their responses in computer generated characters rather than reading the hand writing of the survey responders around the world.

Compared with the other methods - such as interviewing of the experts, observation of the visitors - the online survey directly gathers the attitudes, experiences and data relating to understanding from the many professional museum staffs in their various positions. Observation would be the last process after the results from the online survey were analysed.
5.4.2 Phase 2: Validation of the new classification of ISTEs at the museums of science

The validation at science museums provides for the potential identification of a new classification of interactive science and technology exhibits (ISTEs). Four groups were generated by the author for the new classification. The 10 museums participating in the research consisted of nine museums in the UK, and one museum in Thailand. The following institutes looked at and verified the new classification, namely the 10 dimensions of the cultural issues.


The museum originated in 1857 and has scientific collections of international importance (Science Museum, 2014). The museum has currently many galleries relating to specific subjects such as ‘Energy’, ‘Computing’, ‘Mathematics’, ‘Plasticity’, ‘Who am I?’, and ‘Challenge of Materials’. The ISTEs of the Science Museum in London were observed between 24 – 25 July 2011.

[2] Snibston Discovery Museum

It opened to the public in 1992 at Coalville town, Leicestershire City (BBC, 2014). This museum has indoor and outdoor-exhibit areas. Several galleries were shown in the indoor-exhibit area e.g. ‘the Historic Science’, ‘the Changing of Technological World’, ‘Fashion and Design Collections’, ‘Extraordinary Gallery’, ‘Light Fantastic’, ‘Science Showcase’, and ‘Toy Box’. The outdoor-exhibit area has the ‘Outdoor Play Areas’ and ‘Heritage Railway’ (Snibston, 2014). The ISTEs of the Snibston Discovery Museum were observed on 11 August 2011.


It opened to the public in 1849 at the historic New Walk area of the Leicester city (Art Fund, 2014). The New Walk Museum & Art Gallery has various areas of subjects, displays and collections in art history, cultural and the natural world such as the ‘Ancient Egypt Gallery’, ‘Arts & Crafts Gallery’, ‘Dinosaur Gallery’, ‘Wild Space’, and ‘Picasso Ceramics’ (Leicester City Council, 2014). The ISTEs of the New Walk Museum & Art Gallery was observed on 9 July 2012 and 16 July 2012.
It opened to the public in 2001 (Mullen, 2014). More than 200 hands-on exhibits on science and technology from the past, present and future were provided in the Thinktank. The exhibits were distributed across the four floors of the building named ‘Millennium Point’ at Curzon Street, Birmingham City (Thinktank, 2014). The ISTEs of the Thinktank was observed on 11 July 2012.

[5] National Space Centre (NSC)
It was the largest domed planetarium and space exploration centre in the UK and was established in 2001 in Leicester city. There are several main discovery galleries in this space centre including the ‘Sir Patrick Moore Planetarium’, ‘The Rocket Tower’, ‘Into Space’, ‘Exploring the Universe’, ‘The Planets’, ‘Orbiting Earth’, ‘Space now!’ and ‘Tranquillity base’ (National Space Centre, 2012; National Space Centre, 2013). The ISTEs of the National Space Centre were observed on 13 July 2012.

This manor house was the birthplace and family home of Sir Isaac Newton, the famous scientist of the UK, in 1642 (National Trust, 2014). It was opened as a science discovery centre to the public in 2008 (Short and Weis, 2013) and has several interactive exhibits relating to scientific fields examined by Sir Isaac Newton (Britain Express, 2014). The ISTEs of the Woolsthorpe Manor were observed on 14 July 2012.

[7] Black Country Living Museum (BCLM)
It was established as the open-air site of several historic buildings and was opened to the public in 1966 by Dudley Metropolitan Borough Council in the area of the Tipton Road, Dudley (Black Country Living Museum, 2014). The ‘Interpretive Exhibitions’ building has a particular area for interactive science exhibits. This gallery has been closed for long term maintenance. However, there are a few ISTEs that appear
in the ‘Interpretive Exhibitions’ building. The ISTEs of the Black Country Living Museum were observed on 17 July 2012.

[8] **Enginuity of Ironbridge Gorge Museum**  
It opened to the public in 2002 and is part of Ironbridge Gorge Museums (Ironbridge, 2014; Visit Heart of England, 2014). Enginuity was established in Coalbrookdale, Shropshire as an interactive design and technology centre with 4 main zones - Design, Materials & Structure, Energy, and Systems & Control (Morgan, 2007). The ISTEs of the Enginuity were observed on 18 July 2012.

[9] **Charnwood Museum**  
The original building of the museum was an indoor swimming pool at the Queen’s Park in the centre of Loughborough town. It closed in 1975 and underwent extensive refurbishing and refitting as a museum. It was re-opened to the public in the late 20th century (Colin Crosby Heritage Tours, 2014). The Charnwood Museum has four main areas of permanent exhibits from the past and present - e.g. archaeology, geology, history, and industries - including audio-visuals, computer, interactive displays, and online exhibits. There are also temporary exhibits which have changed covering national and international subjects (Leicestershire County Council, 2014). The ISTEs of the Charnwood Museum were observed on 27 May 2014.

[10] **National Science Museum, Thailand (NSM)**  
The Science Museum was opened to the public in 2000. At present the NSM in Thailand has three museums which comprise the Science Museum, the National History Museum, and the Information Technology Museum (ASPAC, 2014). The Science Museum provides most of the interactive science and technology exhibits (ISTEs) which cover six main topics – e.g. Electricity, History of Scientific and Technological Inventions, Basic Science & Energy, Science & Technology in Thailand, Science & Technology in Daily Life, and Thai Traditional Technology - for local and international visitors rather than consisting of science collections, educational materials, artefacts and
science activities for school children (NSM, 2014). The graphic panels of the exhibits at the Science Museum have two main languages - Thai and English. The ISTEs of the NSM in Thailand were observed before 2009 because the author had been working as a science educator there, in the Science Museum.

All of these museums have interactive science exhibits and ISTEs, although only some museums - e.g. New Walk Museum & Art Gallery, Black Country Living Museum, and Charnwood museum - provide exhibits relating to art, cultural and natural subjects rather than science subjects.

5.4.3 Phase 3: Overview of the online questionnaire
The online questionnaire comprised the three main processes – target respondents, sampling strategy, and design of the online survey. These are described as follows.

[1] Target respondents
The aim in using the chosen target respondents - the many experts who work at the museums in different cultural regions of the world - was to receive information from them relating to their various experiences and insight into ISTEs and their use. The main target respondents are not only the groups of the museums which have interactive science exhibits, but those museums where the experts have understanding about their visitors’ relationship with interactive science exhibits in terms of the cultural issues. Hence, the experts who were to become the target respondents were selected on the basis of their suitability according to these criteria. The roles/ positions of museum staff defined the expectations in this research could make upon the various groups. Typical characteristics of the typical positions at the museums are defined in the following table.
<table>
<thead>
<tr>
<th>Groups</th>
<th>Typical characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director</td>
<td>Represents the museum to the public, works effectively with staffs and to organise entire departments of the museum (University of Rochester, 2012).</td>
</tr>
<tr>
<td>Exhibit designer</td>
<td>“…is responsible for the visual appearance and coherence of the exhibit. The designer’s expertise assures that the material is set out in an appealing, understandable, and attractive manner” (Munley, 1986, p.31).</td>
</tr>
<tr>
<td>Educator</td>
<td>“… who take on education roles in museum (both paid and unpaid), such as developing exhibits, writing programs, and interacting with the public … ‘educator’ or ‘museum educator’ refer to those paid staff working in museums with education responsibilities that predominantly involve face-to-face interactions with the public” (Tran, 2007, p.278).</td>
</tr>
<tr>
<td>Exhibitor</td>
<td>It was defined as “any person, firm, company, association or organisation to whom space has been allocated for the purpose of exhibiting at the Exhibition and its employees, servants, agents or contractors” (European Brewery Convention, 2007, para.1).</td>
</tr>
<tr>
<td>Researcher</td>
<td>Museum research workers are persons who “plan, organise, and conduct research in scientific, historical, cultural, or artistic fields to document or support exhibits in museums and museum publications” (Occupational Information Network, 2012, para.1).</td>
</tr>
<tr>
<td>Curator</td>
<td>“Curators direct the acquisition, storage, and exhibition of collections, including negotiating and authorizing the purchase, sale, exchange, and loan of collections. They also may authenticate, evaluate, and categorize the specimens in a collection” (U.S. Bureau of Labor Statistics, 2012, para.4).</td>
</tr>
<tr>
<td>Volunteer</td>
<td>Volunteers at museums have three kinds of jobs which are (1) ‘explainers’ who could describe the scientific knowledge handled and displayed by the current exhibits to the visitors, answer questions of visitors and offer general information to the visitors, (2) ‘school/group guides’ who greet and guide tours for school children and others through galleries of museum, and (3) ‘event hosts’ who organise special activities – e.g. birthday parties, meet and greet parties, assist with guide tours, and science demonstrations (Miami Science Museum, 2012).</td>
</tr>
<tr>
<td>Other positions</td>
<td>Any staff at museums who have an experience relating to interactive science exhibits or ISTEs involved with the visitors.</td>
</tr>
</tbody>
</table>

Table 5.2: Typical positions at the museums
[2] Sampling strategy
The sampling strategy was based on the respondents from the populations of the museums in the world. Ecsite (2012), the European Network of Science Centres and Museums, provided the lists of museum contacts which connects 400 science centres and others in 50 countries. In addition, the Asia Pacific Network of Science and Technology Centres, ASPAC (2012) listed its memberships from 20 countries in Asia and the Pacific, Europe, Middle East and North America. These were all promoted on its website.

According to the geographical regions, Murdock (1983) identified the classification of cultural areas (Outline of World Cultures) as Asia, Europe, Africa, Middle East, North America, Oceania, Russia and South America. The United Nations (2009) classified geographic countries into six main areas: Africa, Asia, Europe, Latin America and the Caribbean, Northern America, and Oceania (See in Appendix 8). The cultural regions in this research followed Murdock’s (1983) Outline of World Cultures. Hence, the division of the countries offered to the respondents (the experts) would be classified in the eight main geographical regions of Murdock’s (1983) classification in cultural differences.

[3] Design of the online survey
A title was given to the internet-based survey: ‘The online survey of the cultural issues relating to the inclusive design of interactive science exhibits’. Generally speaking, many countries around the world have their distinctive meanings for their words of ‘culture’ and ‘cultural’, and these were not mentioned in the initial introduction of the online survey. The online survey had 22 questions which were developed into two versions. The first version was tested as a pilot online survey with PhD colleagues of the Loughborough Design School. Then on the basis of this piloting it was improved, including changing images of the examples of interactive science exhibits, correction of spelling mistakes and grammatical errors. The second version was the final version and it was used to collect the data in three sections. Questions 1 to 5 in the first section collected personal information relating to the experts such as name (optional), name of the museum, country, email address and
phone numbers (optional). The second section (numbers 6-8) recorded gender, age range and the positions/roles in their museums. The third section was created to investigate the understanding through the 10 dimensions of the cultural issues. The third section of the final version is reproduced in Appendix 10.

The procedure of the online survey was described as follows.

- **[a] Creating the target list of the museums for the online survey**

  Three processes were carried out to generate a list of science museums and science institutes which had involvement with ISTEs, to be considered for the online survey. Firstly, a database directory of the museums from Ecsite (2012) and ASPAC (2012) were used to create relevant organisations in the six major regions. Secondly, the keywords of these museum names were used to interrogate their websites using various search engines such as Library Catalogue Plus of Loughborough University, Google, Google Scholar, Bing, and Microsoft Academic Search. The list of the museum websites visited was recorded in Microsoft Excel spreadsheet software. The museums (including discovery centres, discovery science centres, science museums and science centres) from the database directory were visited using online tours.

  The online survey in this case study was processed through a web-based questionnaire, the data being collected by BOS, the ‘Bristol Online Surveys’ system. The online survey considered a particular group of experts who had experience of museums and understand the usage and/or development of interactive science exhibits. The experts also understood these exhibits and the visitor behaviour that the exhibits generated. It was especially focused on observations of the experts who had experience of visitors’ behaviour as they related to the interactive science exhibits.

  Some science museums did not have names explicitly incorporating the word ‘science’. However, some of these museums demonstrated their interactive science exhibits on their websites. For example, the Yoho Visitor Centre at the National Parks and National Historic Sites in Canada has an interactive
science exhibit about the story of ancient fossils (Royal Ontario Museum, 2011). Other examples, such as the Planetarium, or the Natural History Museum might have interactive science exhibits in their websites too. These included for example, the Armagh Planetarium in Northern Ireland (Armagh Planetarium, 2009), the Planetario Alfa in Mexico (Planetario Alfa, 2011), the National Museum of Dentistry in the USA (University of Maryland - School of Dentistry, 2011), the Houston Museum of Nature and Science in the USA (HMNS, 2011), and the National Museum of Natural Science in Taiwan (NMNS, 2011). Some of these museums displayed various styles of interactive science exhibits on their websites such as electronic exhibits, mechanical exhibits, indoor exhibits and outdoor exhibits. Generally, the indoor exhibits meant the particular exhibits were fixed inside their building. In contrast, outdoor exhibits are constructed outside their building. Finally, 681 museums were found and recorded in terms of their email addresses, and again classified into eight main geographical regions of Murdock's (1983) Outline of World Cultures into the database directory.

Each one of 681 global science institutes was contacted individually and invited to participate in this case study. Where the institution websites had personal emails of their staff on it such as director, science educators, exhibit designers and other positions, then this information was captured. The emails were addressed to the holder of these positions. However, many museums had an enquiry mail box address for visitors to contact them on their website. The targeted survey respondents sometimes did not reply, but passed the e-mail onto another person in their organisation who was more appropriate for the task.

- **[b] Sending an email with the web link including a reference letter**

More than 681 emails were sent to the respondents. Additionally, some museums provided more than one email address for staff such as personal emails of the museum address and personal private emails in their web pages of general information. The period of the online survey was from 15th March 2012 to 30th August 2012. The maximum number of respondents in the online survey were collected within the period of dates. The emails
attached a web link to the online survey and a reference letter was collected within five months (including start and close date of the online survey). Occasionally, some of these email contacts were rejected as there was no email account when they were sent. It is possible that the staff who were the owners of these email addresses had left the employment of the museums. However, most museums preferred online visitors filling in a query on their web forms. In these cases, the research detail and the web link of the online survey were posted into the web form for the museum contact.

In order to encourage the online participations, a copy of the report on the completed online questionnaire was promised to all experts who completed responses.

- [c] Export the database

The database of the online survey was imported into Microsoft Excel spreadsheet software. Then the results of the data were evaluated and some of the results were converted into the bar charts.

5.5 Results
The three main results were – firstly, the 10 dimensions of cultural issues relating to interaction design; secondly, the validity of the 10 dimensions of cultural issues relating to ISTEs at the museums of science; and thirdly, the results of the online survey.

5.5.1 Phase 1: The 10 dimensions of cultural issues relating to interaction design
There were too many results to read and review for this research project and there were fewer results when the keyword searches were changed. For this reason, ‘cultural dimensions relate to interaction design’ was used in December 2011 as shown in the following table.
<table>
<thead>
<tr>
<th>Database Name</th>
<th>Hits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalogue Plus</td>
<td>9,869</td>
</tr>
<tr>
<td>Peer-reviewed Journals</td>
<td>9,446</td>
</tr>
<tr>
<td>Full Text Online</td>
<td>20,903</td>
</tr>
<tr>
<td>Available in the Library</td>
<td>1</td>
</tr>
<tr>
<td>Cited Articles</td>
<td>1,435</td>
</tr>
</tbody>
</table>

Table 5.3: Search for ‘cultural dimensions relate to interaction design’ in Library Catalogue Plus

Most search engine results of the keyword searches - e.g. Library Catalogue Plus, Google, Google Scholar, and Bing - appeared to repeat the keywords ‘cultural dimensions relate to interaction design’ in several web pages after more than 10-25 web pages were examined.

Consequently, articles appearing after the repetitions began were not scanned. Selected articles were then read and summaries made of their content and significance in relation to cultural dimensions. These summarised contents were organised as a list of the cultural dimensions. If some of these sources contained new content that did not fit the previously identified cultural dimensions, they became a new category. Four further dimensions of relevant cultural issues were identified in this manner. The summary of these 10 dimensions (the original six dimensions and four new dimensions) was characterised as a mind map in the following figure. The four new dimensions were emotional values, age issues, gender issues, and disabled people.
The 10 dimensions of the cultural issues relevant to interaction design were identified as physical skills, technologies issues, language issues, visual cultures, conceptual understanding, social issues, emotional values, age issues, gender issues, and disabled people. Accordingly, the aims of this study were to investigate the 10 dimensions of the cultural issues relating to interactive science and technology exhibits (ISTEs). This will be show in the next section.
5.5.2 Phase 2: Validity of the 10 dimensions of cultural issues relating to ISTEs at the museums of science

Physical skills
The majority of physical skills used by visitors for interaction with exhibits are manual skills for manipulating part or parts of ISTEs. Currently, the advanced models of various ISTEs of the research museums tend to combine high technologies such as electronics, computer controllers, and sensors. These are operated using visitors’ physical skills and involve various body parts such as the skills of fingers, palms, hands, feet, eyes, head, voice, and body movements. Also manual skills were common skills which were generally found to be essential for exploring the interactive exhibits. For instance, most interactive models have been designed to be controlled by manual skills such as pushing a button, rotating a ball and touching a metal plate. On the contrary, foot skills might be used in any group of the interactive exhibits, but less frequently than hands skills. Foot operation may be avoided for two reasons. Firstly, it is inconvenient for many visitors who have footwear and need to take them off before they can participate in the use of the exhibits. Secondly, while the visitors kept their shoes and socks off; their feet may have an unpleasant odour, which other visitors will not like. Therefore most exhibit designers have not developed interactive science exhibits which use toes to operate.

The physical skills of the ISTEs were identified in the groups as follows. See Chapter 4 for explanation of the classification.

- **Group 1 [Simple interaction with direct understanding]**
  The physical skills which appeared in the exhibits such as using eyes to observe the exhibit, the manual skills - using hand(s) or finger(s) to press a button, push a ball, slide any object, turn a disc, lay down on the plate, throw a ball, rotate a handle, grab a bar, hit the material and the foot skills such as stepping down or jumping on a metal plate. In addition, most exhibits in this group were operated by only one hand or one finger.
An example is the ‘Multiplication’ exhibit illustrated in the following figure at the NSM. The visitor needs to use their finger, and skill is important to press on the buttons relating to the price numbers - e.g. plastic models of fruits or vegetables appear inside a basket on the table to show on the screen monitor the same number of these plastic models. However, visitors may make a mistake in their finger skills with the pressing times of the correct price on any button. If they make a mistake, they can restart by pressing a new button to clear the previous number.

![Multiplication exhibit](image)

**Figure 5.2: ‘Multiplication’ exhibit**

- **Group 2 [Simple interaction with complex understanding]**
  The physical skills were connected with the exhibits in the same way as in group 1. For instance, manual skills are applied by using the hands to drag a string to measure a distance, grab one material to rub or touch with other materials, turn a disc, lay down on the plate, rotate a handle, grab a bar, hit the material and slide materials.

  The first example, the ‘Static electricity’ exhibit in the following figure at the NSM is one where visitors rub each one of four materials in various ways such as rubbing the materials from left to right, or from right to left, or rubbing the materials away from their bodies or towards their bodies. However, it is possible that some visitors did not read the graphic explanation and might hit on the cloth on the right-hand side rather than rub on it. The visitors might carry one type of material for touching many small pieces of silver plastics by the same hand on the left-hand side of the exhibit again. Finally, the visitors need to compare which one of these materials has impregnated static charge on the
surface of many small pieces of the silver plastics. The Static electricity exhibit was hard to understand for general visitors, because the exhibit showed only some materials which could create static electricity such as a plastic and a rubber object. The experiment of the exhibit did not make it clear to the visitors what was happening, and in what way these materials that retained static electricity differed from other materials such as wood and stainless steel.

![Figure 5.3: ‘Static electricity’ exhibit](image)

- **Group 3 [Multiple interactions with direct understanding]**
  For this group, the physical skills were related to the exhibits in which the visitors need to compare various results of scientific experiment using the exhibit. Multiple interactions were used by visitors to investigate some of these exhibits such as manual skills when using hands to lift up each object or using the voice for speaking into each of the different sized tubes. With some exhibits in this group, the visitors needed to interact in steps which involve many options.

  The first example is the ‘Newton and the Apple’ exhibit in the following figure at the NSM where the visitors need to lift up any one of the four balls or move up all four balls together requiring a number of visitors to operate this stage at the same time. Then the visitors pushed a button on the right-hand side of the exhibit to make all the balls fall down at the same time.
The second example, the ‘Wobble Proof’ exhibit at Enginuity (illustrated in the following figure) invites the visitor to use their sophisticated hand-skills to build up two levels of a structural model from several pieces of plastic. Then the visitor must thrust a lever handle to the ‘Fast’ (up-position) or the ‘Slow’ (down-position) and cause the structural model to wobble until it collapses. If any visitor can build a strong structure model, then this will rarely break down after the fast-wobble process. There are two sets of this same experiment in the ‘Wobble Proof’ exhibit.
Group 4 [Multiple interactions with complex understanding]

Multiple interactions involving physical skills were used to investigate the exhibits by for example manual skills of turning each knob to compare the weight of material, pushing down the ball and the cube into the sand. The visitors need to understand the various steps of their multiple interactions which relate to the science which underpins the exhibits. It was complex understanding when the visitors investigate science embodied in the exhibits, through their multiple interactions.

The first example, the ‘A New World’ exhibit, illustrated in the following figure, at the Woolsthorpe Manor provides visitors with an understanding of Newton’s speed experiment. The visitor(s) are provided with a black rubber paddle which contains a hidden speed detector sensor in a white bar. The exhibit has 3 buttons - (1) ‘next frame’, (2) ‘retry experiment’, and (3) ‘push to go back to beginning’ – and the visitor has to push one of these. The visitor should slowly move the black rubber paddle in the vertical plane. The visitor can view the monitor which will describe the next action to initiate the next experiment. Many children had difficulty with the level of hand skills required – they preferred to lay down the black paddle rather than sliding it in the vertical plane. Also no image was provided to show how to hold the paddle in the correct position in their hand.

Figure 5.6: ‘A New World’ exhibit
The second example, the ‘Gears and how they work’ exhibit in the following figure at the NSM in which one visitor or more than one of the visitors has to turn any of three knobs which are connected to the gears. Also one visitor could turn any two knobs together in order to compare the weights of the objects.

Figure 5.7: ‘Gears and how they work’ exhibit

Technologies issues
The technological components of the exhibits usually comprise an electronic switch which could operate as an external component. Other external technological devices were always found in the interactive exhibit such as electronics for lighting and sound components. The visitors always interacted with them directly such as seeing the light and hearing the sound. Other internal technological components of the exhibits often used are an electric motor and a dynamo. The visitors could not always see them directly, because sometimes these electronic devices were concealed inside the exhibits.

If ISTEs had technologies issues, there were significant characteristics of technology relating to the four groups as follows.

- **Group 1 [Simple interaction with direct understanding]**
  Many interactive exhibits have offered technological devices to the visitors such as an electronic switch button to turn on and off, or plugging poles for connecting an electric board. Then the exhibits responded with movements such as rotating, running, flying, jumping and sliding. In addition, the exhibits might emit light and/or a sound.
The first example, the ‘Scan it’ exhibit is illustrated in the following figure at ‘Enginuity’. The exhibit provides a remote control handset for the visitor(s) who use the handset to point to these objects - e.g. car engine, wind pump, jet engine, and bicycle – which have a label with the question mark symbol on them. There is an optional extra, the visitor can also press a button beside the screen monitor, on which appears the object quiz and then the handset is used to point to the objects. The exhibit has two boxes of information screen monitors, with their handsets on opposite sides to each other. However, only a few objects can be demonstrated to work by themselves rather than by observing as an inactive object e.g. if visitors can press buttons to demonstrate car engines working.

![Figure 5.8: ‘Scan it’ exhibit](image)

The second example is the ‘The elements in water’ exhibit in the following figure at the NSM where the visitor needs to press an electronic switch to start a process of water electrolysis.

![Figure 5.9: ‘The elements in water’ exhibit](image)
- **Group 2 [Simple interaction with complex understanding]**

  Many ISTEs have offered technological devices as in the case of group 1. The exhibit in this group could demonstrate the existence of magnetic forces, electromagnets and static electricity. The visitors need to investigate and perform various experiments using the exhibits.

  An example is the ‘Short measure’ exhibit at the NSM where the visitor needs to press a grey bar in front of the exhibit. Then a laser beam will be emitted through a lens and is projected onto a small white screen. This laser beam in terms of its technologies issues is too complex for visitors’ understanding. There is no diagram on the graphic panel to explain clearly how the beam is projected onto the white screen and why it is called ‘short measure’.

  ![Figure 5.10: ‘Short measure’ exhibit](image)

- **Group 3 [Multiple interactions with direct understanding]**

  Many interactive exhibits have offered technological devices which could support many visitors using it at the same time with similar form of interaction.

  For example, the ‘how hot are you?’ exhibit in the following figure at the NSM showed the technological electric heating plates and plastic materials for measuring the temperatures. Two or three visitors could lay their hands on the plates and plastic materials of the exhibit at the same time.
Group 4 [Multiple interactions with complex understanding]

Many interactive exhibits in group 4 have offered technological devices which are the same as in group 3. However, some technological devices might appear unpredictable in their features offered and in the nature of the interactions generated, so that the visitors may not know how to use the exhibit. For instance, most visitors have not seen the ‘plasma ball’ exhibit at the NSM in the following figure which emitted colourful sparking lights inside its sphere. The visitors might not know they could use their fingers or hands to touch the surface of the plasma sphere. Some visitors only looked at the plasma ball and took some photos; some visitors might be fearful of the exhibit, imagining it could be harmful, and they just avoided using it.
In the literature review, the technologies issues relating to the cultural dimensions could be broken down into two main topics - Human Computer Interaction (HCI) and User-Centre Design (UCD) as follows.

**Human Computer Interaction (HCI)**
At present, many interactive exhibits in the museums e.g. the London science museum, the National Space Centre in the UK, and the NSM provided computers which were merged together with other technological components such as webcam (web camera), touch screen monitor, microphone and speaker. Hence, the visitors who came from a country where computers were not used widely need to learn how to interact with the computers.

The HCI was identified in the 4 groups as follows.

- **Group 1 [Simple interaction with direct understanding]**
  HCI was found in the exhibits which have the computer's components.

  For example, the ‘What’s in a surname?’ exhibit at the Science Museum in London in the following figure showed a question which the visitors needed to type their family name by using one finger for touching each alphabet on a monitor. The existence of their last name would show on the screen as a map of the Great Britain.

  ![Figure 5.13: ‘What’s in a surname?’ exhibit](image)

- **Group 2 [Simple interaction with complex understanding]**
  HCI was found in these exhibits as in group 1.

  For example, the ‘Genetic testing’ exhibit at the Science Museum in London in the following figure which the visitors could use only one
finger to click on its buttons for ‘Yes’ and ‘No’. Complex understanding is involved because it needed more information to be read setting out clearly the ways to interact with the exhibit, and providing an explanation about the meaning of the genetic testing.

![Figure 5.14: ‘Genetic testing’ exhibit](image)

- **Group 3 [Multiple interactions with direct understanding]**
  
  HCI was found in these exhibits as in group 1 and group 2.
  
  The first example, the ‘Agetron’ exhibit at the Science Museum in London in the following figure comprised the components of a touch screen monitor, light bulbs and a capture camera. The visitor could interact with the exhibit by pressing the buttons for taking their photo through the web camera with illumination of the field of view by means of bulbs. Then the visitor needed to press other buttons on the computer screen to adjust their photo’s face to appear younger or older.

![Figure 5.15: ‘Agetron’ exhibit](image)

The second example, the ‘Visit the Space Station’ exhibit at the Thinktank, illustrated in the following figure, provides one or two visitors with seating to sit and to operate two handle controllers. One lever moves in two directions (front-back) located on the left-hand side and a joystick with four directions of movement (left-right-front-back)
located on the right-hand side for moving a pointer on a concave
curved screen monitor. Visitor(s) should watch the screen monitor and
listen to the speakers output to receive information on how to operate
this exhibit.

![Figure 5.16: ‘Visit the Space Station’ exhibit](image)

- **Group 4 [Multiple interactions with complex understanding]**

  HCI was found in these exhibits as in all groups.

  The first example, the ‘Exploring the climate system’ exhibit at the
  Science Museum in London in the following figure is controlled by
  visitors waving their hands through the air in front of a monitor. The
  visitors could move either hand from their left to right-hand side
  through the air causing the spinning of a virtual globe’s simulation on
  the screen. The visitor could also wave their hand to zoom in and
  zoom out of the virtual earth. However, the visitors might find it too
  complicated to understand how to control the image on the monitor
  representing the information about climate change. In addition, the
  visitors needed to find out a way of using their hands to interact with
  the screen by themselves, such as gesturing to operate zoom in to
  move into the virtual earth.
The second example, the ‘Explore the internet’ exhibit at the Black Country Living Museum (BCLM) illustrated in the following figure provides a screen monitor and a keyboard for visitors searching for the information about museums on the internet. Visitors need to understand how to type on the keyboard whilst rotating a ball to point a cursor on the screen monitor. However, this exhibit is classified as ‘complex understanding’ because visitors need to read through the information provided; they should have existing experience of using computers and internet, and then work out in their own mind what to do.
User-Centred Design (UCD)
The exhibits were classified in the UCD as follows.

- **Group 1 [Simple interaction with direct understanding]**
  User-centred design was found in such cases as the switched buttons in a suitable position for seeing and pressing.

  The first example, the ‘Send the train on its way’ exhibit in the following figure at the NSM had a sloped angle towards the visitor who could easily see a button to press it. Also the height of the exhibit was suitable for young children and adult visitors to both see a small train run.

![Figure 5.19: ‘Send the train on its way’ exhibit](image)

The second exhibit, the ‘Astronauts and Science: go hand-in glove’ exhibit is illustrated in the following figure at the National Space Centre. This ISTE invites visitors to put their hands through a glove which is joined to a model made up of small pieces of coloured plastic models together as the same simple way for using both of their hands. The two hollow channels are designed as a simple UI for visitors understanding that they must enter their both hands into these two gloves. The appearance of this exhibit interface (UI) with two holes (round) for two hands and glove behind each round hole is self-explanatory to the visitor. This exhibit has also a little stool for use by a young child to stand on so they can put their hands into the gloves at
the same level as adults. Another visitor could help by using one of their hands working with one hand of the first visitor. This would be an unusual operation; this exhibit should be classified as a ‘simple interaction’ exhibit rather than ‘multiple interactions’ exhibit.

![Image](image_url)

**Figure 5.20:** ‘Astronauts and Science: go hand-in glove’ exhibit

- **Group 2 [Simple interaction with complex understanding]**
  
  User-centred design was found as in group 1; some exhibits were easy for handling.

  For example, the ‘Ball Bounce’ exhibit at the ‘Enginuity’ illustrated in the following figure which enables visitors to investigate four balls of different materials - e.g. nitrile rubber, polypropylene, nylon 66, and acrylic - to release them down their tube and assess the height to which they bounce. The visitors press a button in front of each tube of these materials. Visitors may spend more time to observe and compare the results of these different balls and materials and their bouncing performance. The design (in terms of user centred design) of this exhibit is simple for visitors’ interaction but they need more information about the properties of these materials which should be provided on the graphic panels.
Group 3 [Multiple interactions with direct understanding]

User-centred design was found in group 3 as in group 1 and group 2.

For example, the ‘Who am I? Am I like my parents?’ exhibit at the Science Museum in London in the following figure has a white screen which projected several sizes of small coloured dots’ movements. Many dots followed the body movements of any visitor who stayed in front of the white screen creating colour shadows.

Figure 5.21: ‘Ball Bounce’ exhibit

Figure 5.22: ‘Who am I? Am I like my parents?’ exhibit
• **Group 4 [Multiple interactions with complex understanding]**
User-centred design was found in this group as in all groups.

The first example, the ‘Fluidised bed’ exhibit at the NSM in the following figure had two gloves which visitors could put their hands into and grab a ball and a cubic. The ball and the cubic were laid on white sand in a tank which was covered by transparent plastic. The gloves were suitable for any sizes of visitors’ hands because the end of the gloves had a rectangular shape preventing visitors from inserting their fingers to the end of the gloves. However, some visitors might think sharing the two gloves with other visitors was not hygienic.

![Image](image.png)

*Figure 5.23: ‘Fluidised bed’ exhibit*

The second example, the ‘Penny Press’ exhibit at the Black Country Living Museum (BCLM) illustrated in the following figure requires visitors to insert two coins into the slot and rotate a steering wheel. Then visitors can get a penny stamped and another coin does not return for paying the cost of the service from this exhibit. However, some parts of this exhibit may not have involved UCD in its design because the slots for inserting the two coins is at too high a level for young children, and there is no stool provided for young visitors to stand on at an appropriate height while they are using it.
The current research of inclusion of UCD is divided into 2 parts - User Interface design (UI) and Cultural User Interface (CUI), and the results are shown in the following.

**User Interface Design (UI)**

The UI needed to be developed for many types of equipment including the interactive science exhibits. UI was identified in the groups as follows.

- **Group 1 [Simple interaction with direct understanding]**
  
  UI was apparent in some exhibits such that they appeared to have a similar layout to that on the screen of the computer.

  For example, the ‘Wind power’ exhibit at the NSM in the following figure showed the models of a modern wind turbine and a traditional windmill. The models could be explored by visitors to determine which one was more efficient. The UI of the exhibit made for easy understanding of both wind powers, and made comparison of the two types a simple task.
Group 2 [Simple interaction with complex understanding]

UI found in some of these exhibits was similar to those in group 1.

The ‘Odonata: Dragonflies and Damselflies’ exhibit at the ‘Wild Space’ gallery of the New Walk Museum & Art Gallery in the following figure. Visitors can use only one finger to operate black toggle-switch ‘focus’ buttons to control the focus in-out on the left-hand side. The visitors can also operate a ‘zoom’ button to control zooming in-out on the right side. These buttons control the focus/zoom of the microscope. This device magnifies images of the specimens - dragonflies and damselflies on the trays and projects the image on a screen monitor. However, this exhibit involves complex understanding on the part of the visitor(s) to distinguish between dragonflies and damselflies without any help, and they must read the graphic information to understand clearly these specimens on the tray.

Figure 5.26: ‘Odonata: Dragonflies and Damselflies’ exhibit

Group 3 [Multiple interactions with direct understanding]

UI found in some exhibits was similar to those in group 1 and group 2.
For example, the ‘Heat on the move/conduction’ exhibit at the NSM in the following figure had three metal plates of dissimilar materials which were formed into hand shapes. The visitors could easily understand the symbol portraying the laying of their hands on the plates.

![Figure 5.27: ‘Heat on the move/ conduction’ exhibit](image)

- **Group 4 [Multiple interactions with complex understanding]**
  UI was similar to the other groups.
  
  For example, ‘Batteries’ exhibit at the NSM in the following figure showed the interface design of a hand symbol which was placed in the vertical line.

![Figure 5.28: ‘Batteries’ exhibit](image)

**Cultural User Interface (CUI)**

The Cultural User Interface (CUI) or cross-cultural interfaces were the interface designs which appeared in the exhibits. The visitors might be
familiar with the exhibits in their CUI. The CUI was identified in all groups of exhibits as follows.

- **Group 1 [Simple interaction with direct understanding]**
  CUI was found in some exhibits.

  For example, the ‘Solar power’ exhibit at the NSM in the following figure demonstrated the modern technology of solar cells. A model house in the exhibit was a modern house style in Thai culture. The familiar furniture and electronic equipment in the house could be shown, which could help Thai visitors to comprehend what solar cells are used for.

![Figure 5.29: ‘Solar power’ exhibit](image)

- **Group 2 [Simple interaction with complex understanding]**
  CUI was found in some exhibits as in group 1.

  For example, the ‘Fossil power’ exhibit at the NSM in the following figure showed a model of a coal mine with trucks, mountains, buildings, and trees displayed in an environment perceived by visitors as a simple cultural user interface. The natural environments such as mountains and trees might help the visitors to understand where the fossil power came from. However, the ‘Fossil power’ exhibit is complex for visitors to understand because the exhibit did not explain what would be done after the two trucks had carried coal and travelled around the coal mine.
Figure 5.30: ‘Fossil power’ exhibit

- **Group 3 [Multiple interactions with direct understanding]**
  CUI was found in some exhibits as in group 1 and group 2.

  The ‘Useful fiction exhibit’ at the NSM in the following figure showed a wheel of a car which appeared as a cultural user interface. Most people in the world have seen various types of wheels on different vehicles such as a bicycle, a car, and a truck as part of their culture in their daily life. Some underdeveloped countries are possibly still using wheels made from wood such as cart’s wheels.

Figure 5.31: ‘Useful fiction’ exhibit

- **Group 4 [Multiple interactions with complex understanding]**
  CUI was found in some of these exhibits as in all groups.

  The first example, the ‘Cranes and pulleys’ exhibit at the Charnwood museum is illustrated in the following figure. This provides two sizes of pulleys – the left pulley is a large size and the right pulley is a small size. The pulleys are designed to work with small gears behind two knobs. One or two visitors can operate these two model cranes by their hands in different rotations - clockwise and anti-clockwise - by
turning the two knobs. The two model cranes will move two weights up or down inside their transparent plastic tubes. The speed of movement of the weights can be compared and related to the pulley size i.e. the number of rotations producing a given movement in the plastic tunnel. However, these small model cranes are unusual objects for visitors in some countries where they may have never seen a large crane, illustrating technologies issues. It is also possible that some visitors may think these small cranes are toys rather than representations of really useful mechanical tools in their lives.

![Figure 5.32: ‘Cranes and pulleys’ exhibit](image)

The second example, the ‘Real image’ exhibit at the NSM in the following figure displayed a large bowl which was the same shape, large size and black colour as an Asian cooking pan. The shape and style of the cooking pan was very well known for use in Asian countries such as in China and Thailand. However, most people in the UK and the USA use a different type of cooking pan, and this large black pan shape would be unfamiliar.

![Figure 5.33: ‘Real image’ exhibit](image)

**Language issues**
Language issues and the meanings of scientific words were very important if visitors were to understand the exhibits clearly. For instance, some ISTEIs at the NSM consist of imported exhibits which have become permanent exhibits. A number of these exhibits were initially rented as temporary exhibits. Hence, the graphic panels of these exhibits were published in two languages in Thai and English, the latter version for international visitors. Moreover, if the exhibits came from China, the graphic boards were translated from Chinese into Thai language. This demonstrates that the language issues seem to be relevant in all four groups of the interactive exhibits, as follows.

- **Group 1 [Simple interaction with direct understanding]**
  Many scientific words were found in the exhibits such as geometry, gravity, Pythagoras, Bernoulli, convection, power and elements. Although these words translated into other languages, the exhibit might need to give these words’ definitions.

  The first example, the ‘Gravity and plants’ exhibit in the following figure at NSM where the word ‘gravity’ might appear as an abstract and unusual word to many international visitors.

![Figure 5.34: ‘Gravity and plants’ exhibit](image_url)

- **Group 2 [Simple interaction with complex understanding]**
  Many scientific words were found in the exhibits such as geometry,
gravity, crystals, nuclear, power, fossil, hyperbola, electromagnets, static electricity.

For example, the ‘Crystals’ exhibit at the NSM in Thailand in the following figure where the visitors needed to understand the meaning of the word ‘crystals’. In the UK, the word ‘crystals’ - some people might think it is a kind of jewellery. In Thailand, there is no universally understood meaning for this word.

![Figure 5.35: ‘Crystals’ exhibit](image)

- **Group 3 [Multiple interactions with direct understanding]**
  Many scientific words were met in the exhibits such as centrifuge, Newton’s laws, pulleys, friction, conduction, radiation, echo and vocal cords.

  For the ‘Heat on the move/radiation’ exhibit at the NSM in the following figure, it appears that many visitors might not understand what the word ‘radiation’ means.
The second example is the ‘I am a ... and I eat ... ’ exhibit at the ‘Wild Space’ gallery of the New Walk Museum & Art Gallery where visitors use one hand to slide up a small handle and ‘pull the lever’ to open a new question on one of three rotating panels on a screen, e.g. a panel of animals and one or two kinds of their food on the other two panels. Then visitors may discover information about the relationships of animals to their foods by using one of their fingers to press on any of these 3 scientific words - Carnivore, Herbivore, and Omnivore - e.g. ‘I am a ... and I eat ... and that makes me a ...’. Relating to the image below of an animal and two foods: ‘I am a bear and I eat berries, fish and I am omnivore’. If the visitor(s) presses a button with the right answer, a light will appear with the word ‘correct’. However, if they press the button with the wrong answer, the light does not appear so the word ‘correct’ is not presented.
- **Group 4 [Multiple interactions with complex understanding]**
  Various scientific words such as coil, gears, plasma, fluidised bed, power, fibres and real image were displayed in the exhibits.

  The first example, the ‘Optical fibres’ exhibit in the following figure at the NSM where the word ‘fibre’ was unknown to most people. Some people might understand it as a biological word relating to high fibre food. The word ‘fibre’ appears in the nutrition resources as advertised on cooking television programmes in many countries, such as in the UK and in Thailand.

  ![Image of Optical Fibres exhibit](image)

  **Figure 5.38: ‘Optical fibres’ exhibit**

  The second example, the ‘Health: Healthy babies’ exhibit at the Thinktank illustrated in the following figure allows visitors to sit down on a blue seat to operate a microscope using both hands – e.g. one hand to adjust an eye piece lenses to fit on the visitor’s eyes and the other hand to operate two red handles to catch and release a sperm in the microscope slide. However, the two red handles are located in inappropriate positions underneath the base of the microscope where visitors cannot easily find and use them. It is difficult to operate both handles when the visitor needs one hand to control the sperm in the microscope slide. Then visitors need to answer questions about sperm relating to healthy babies and to do this they must operate a touch screen monitor. This exhibit has many scientific words - e.g. sperm, cell, embryo, Huntington's disease, Fragile X Syndrome, Cystic
Fibrosis, and Thalassaemia – and these appear on the screen monitor.

**Figure 5.39: ‘Health: Healthy babies’ exhibit**

**Visual cultures**

Visual cultures might be offering different experiences to international visitors. The dissimilarity of visual cultures could make people misunderstand what the visual objects were showing. For instance, some science museums prepare metal graphic plates of Braille characters for use by blind people. If international visitors in some countries using such exhibits had never seen or heard of Braille characters before; they could not possibly understand what the many dots of the Braille alphabets were. This ‘aid’ would be entirely meaningless to the visitors and make the exhibit meaningless too. Perhaps international visitors had not seen any previous objects in the exhibits before such as the model of the house’s style, the car wheel, and the cooking pan. This could mean the visitors do not understand the meaning of the exhibits’ display. Hence, the cultural user interface could remind international visitors about the cultural issues which might impair their understanding of the exhibit. It appears that different visual cultures occur in many ISTE’s which may reflect the different visual cultures in many countries.

The visual cultures were identified in the groups of the new classification as follows.

- **Group 1 [Simple interaction with direct understanding]**
  Visual cultures were apparent in many exhibits in shapes, symbols, colours, styles, patterns and models. Some symbols were recognised
as having the same meaning in all cultures e.g. dangerous if the exhibit was touched.

An example of visual cultures in a symbol was the ‘Heat on the move/convection’ exhibit at the NSM in the following figure which had an image of a fire in front of a glass. The visitors might not understand that in order to interact with the fire symbol in the exhibit, they must touch the glass to see convection illustrated.

![Figure 5.40: ‘Heat on the move/ convection’ exhibit](image)

- **Group 2 [Simple interaction with complex understanding]**
  Visual cultures were found in many exhibits as in group 1.

  An example of visual cultures in colours was the ‘Nuclear power’ exhibit in the following figure at the NSM showed red and blue lights. The visitors needed to press two buttons for reducing or increasing pressure in a cooling water unit of the exhibit. Visual cultures appeared in the colour of red lights of the alarm of the nuclear reactor which were lit when there was too much heat. Some international visitors might feel frightened when many red lights came on with the alarm.

![Figure 5.41: ‘Nuclear Power’ exhibit](image)
Group 3 [Multiple interactions with direct understanding]

Visual cultures occurred in many exhibits as in group 1 and group 2.

The first example, visual cultures in a diagram – the ‘Vocal Vowels’ exhibit in the following figure at the NSM showed many diagrams of human vocal cords’ working. This illustration visually was an aid to visitors understanding how the voice is generated.

![Image of Vocal Vowels exhibit](image)

Figure 5.42: ‘Vocal Vowels’ exhibit

The second example, the ‘Work the digger’ exhibit at the Thinktank illustrated in the following figure where the visitor operates four levers to control the digger arm used to transfer balls. The three levers (two levers in the middle and one on the right-hand side) operated three parts of the digger in the directions - up and down. Only one lever is located on the left-hand side of the console to control the direction of the digger arm from left to right. Also the console shows the four images of the digger arm’s direction above the four levers. This console may confuse the visitor and impair their interactions. The graphic panel is redrawn as a simple shape of a digger arm, similar to the original images. The A-B-C labels are the positions at the three joints, and the 1-2-3-4 labels are the numbers of the four levers e.g. the lever 2 should control joint A rather than joint B and lever 3 should control joint B rather than joint A. On the other hand, if the position of lever 2 was changed to that of lever 3, this would significantly help the visitors’ performance when digging for balls. However, the visitors may need to spend time practising how to use these four levers in order to produce the appropriate movements and correct positions of the digger arm. This design of controls is completely different to the
design for commercial machines produced globally. They use two joystick controls with a switch on the top of one of these joystick controls. This is a much more ergonomic design and is far easier to use and much quicker to learn to use.

![Joystick Controls](image)

Figure 5.43: ‘Work the digger’ exhibit

- **Group 4 [Multiple interactions with complex understanding]**

  Visual cultures occurred in many exhibits as in group 1, group 2, and group 3.

  For example, visual cultures in a model was the ‘Sound waves and musical notes’ exhibit at the NSM in the following figure. In this exhibit, visitors could sit down and use their hands to play a large musical keyboard or step on this keyboard with their feet using one of a series of options which are based on the different cultures. Also this exhibit is complex - it demonstrates an image of sound waves on the graphic panel which does not represent the sound waves coming from the large musical keyboard.

![Sound Waves Exhibit](image)

Figure 5.44: ‘Sound waves and musical notes’ exhibit
Conceptual understanding

Many people in their societies might have different conceptual understandings from their societies. This may be particularly true in the scientific conceptual understanding associated with the science museums. The ISTEs at the research museums were classified in terms of conceptual understanding as follows.

- **Group 1 [Simple interaction with direct understanding]**
  Conceptual understanding was required in various scientific topics of the exhibits such as light, power, force and mathematics.

  The first example, the ‘Pepper’s ghost’ exhibit at the NSM in the following figure demonstrated the reflection of light. The visitor needs to press a button providing a simple interaction and then a small model of a woman appears on a wall of the Thai style house. The model woman represents a virtual ghost which will disappear, if the visitor releases the button. If the exhibit did not show a structural diagram of the reflection; it was possible young children and students would misunderstand this exhibit and imagine that they could see a real ghost. This was made more probable because the exhibit showed the small model woman wearing a traditional style Thai costume just like the Thai ghost in Thai films.

![Figure 5.45: ‘Pepper’s ghost’ exhibit](image)

The second example, the ‘Continuous Rotary Motion’ exhibit at the Charnwood museum illustrated in the following figure, provides a visitor with a button which they must press and hold. Then a magnetic
bar will spin around the middle of six electro-magnets radially positioned. As spinning occurs, this will light a series of red lights in a clockwise direction. The visitor has to directly use their thought to work out how to operate the exhibit. The exhibit does not have any diagram or description of the scientific concept explaining how the magnetic bar relates to the electro-magnets.

Figure 5.46: ‘Continuous Rotary Motion’ exhibit

- **Group 2 [Simple interaction with complex understanding]**
  
  conceptual understanding was found in various scientific topics of the exhibits such as gravity, solar system, forces, magnets, static electricity, power, nuclear, and mathematics.

For example, the most famous misunderstanding of a scientific idea was gravitation - Sir Isaac Newton was the British scientist who discovered this theory of the physical nature. The ‘Gravity and the solar system’ exhibit in the following figure at the NSM needed visitors to release a small ball into the bottom of a central hole in its big bowl. Visitors needed to connect the scientific concept of gravity and the solar system themselves without assistance from the exhibit. The exhibit might give the visitors a misconception of the solar system. This is because the solar system does not have a hole in its centre.
Group 3 [Multiple interactions with direct understanding]

Conceptual understanding was evident in several scientific topics such as force, sound, heat, temperature, viscosity, friction, radiation and conduction.

For example, the ‘Pulleys make lifting easier’ exhibit in the following figure at the NSM where the visitors could misunderstand the scientific principles involved in pulleys, because the exhibit did not have a diagram showing how the force visitors can exert is amplified by the pulley mechanism. Potentially, the exhibit could help visitors to understand pulleys and realise if there were more pulleys; they could lift the objects easily.
Group 4 [Multiple interactions with complex understanding]

Conceptual understanding was found in several scientific topics such as refraction of light, electricity, gears, fluidised bed, plasma, sound waves, real image, lenses and power.

For example, the ‘Shadow on Screen’ exhibit at the NSM in the following figure showed a luminescent screen which was coated with a phosphorescent dye. The visitor’s shadow would appear on the screen because the flashlight had emitted on the screen in seconds. Some areas of the screen behind the visitors became their shadow. Although the visitor moved away from the screen, the shadow was still remaining on it because the phosphorescent material of the screen glowed in the dark. The visitors needed to link the fact of the screen’s luminescence and the emission of light and creation of shadow together. They then had to understand the scientific concept by themselves because they had no help from the exhibit, and there were no museum staff in that area to explain the information to them. It was probable in these circumstances that the visitors would misunderstand the scientific concept illustrated by this exhibit because the exhibit did not foster understanding in visitors by helping them with - for example a diagram of how it worked.
Social issues
The social issues were apparent in the social situations involved with the interactive science and technology exhibits (ISTEs). These types of issues involved particular agreement by most people in each society. For example, British people will wait for any services in an orderly queue such as in the post office, at the bus stop and at the bank. Most British people are agreed on this principle, respect it, and wait in line as a standard rule. The social issue for waiting in queue might affect visitors’ behaviour at science museums. Some ISTEs needed to be operated together by many visitors. So many visitors could spend their time sharing in the participation of an exhibit’s experiment.

The social issues are perceived as behaviours in Western cultures appeared in all groups as follows.

- **Group 1 [Simple interaction with direct understanding]**
  Social issues were found in group 1 such as waiting in a queue and sharing the exhibit’s participation. However, it was noted that exhibits were built in around a shape so visitors could participate on more than one side.

  The first example is the ‘Block Printing’ exhibit in the following figure at the Snibston Discovery Museum where the young visitors learned the ways of printing.
Figure 5.50: ‘Block Printing’ exhibit

The second example, the ‘Rocket Builder’ exhibit is illustrated in the following figure at the National Space Centre which requires young visitors to use their hands to move and paste several pieces of printed image on the magnets. These images together should generate the shape of the space rocket model on the metal wall.

Figure 5.51: ‘Rocket Builder’ exhibit

- **Group 2 [Simple interaction with complex understanding]**

Social issues were found as in group 1.

For example, in the ‘Addition - how fast are you?’ exhibit at the NSM in the following figure, visitors might be confused because they could participate with others or the visitor could interact by alone. Both abacus and calculator were shown in the exhibit and it was not made clear that it could be used by one or more visitors. Visitors had to work this out for themselves.
Social issues were found as in group 1 and group 2.

The first example, the ‘Echo chamber’ exhibit at the NSM in the following figure was where the visitors could interact with the exhibit with a maximum of three visitors with one visitor per each large channel. Visitors could directly understand the word ‘echo’ which is not a scientific word. Whether they speak into these channels, they will hear their sounds’ reflection. Also, they can communicate to other visitors using these channels as social interaction.

The second example, the ‘Speaking tubes’ exhibit at the NSM illustrated in the following figure produces various tones of human sounds through four tubes of different sizes. These tubes are placed in positions parallel to each other, where visitors wait in a queue to change to other tubes.
- **Group 4 [Multiple interactions with complex understanding]**

  Social issues were found as in other groups. However, if the exhibits were very popular, there could be crowds of visitors which required visitors to wait in a queue.

  For example, the ‘Coloured light’ exhibit at the NSM illustrated in the following figure which visitors could interact with others. One visitor could press a button and another one could turn a rotating screen.

  ![Figure 5.54: ‘Speaking tubes’ exhibit](image)

  ![Figure 5.55: ‘Coloured light’ exhibit](image)

**Emotional values**

Some ISTEs at the research museums may not support emotional values and have an impact on their visitors e.g. visitors just looked around and walked pass ISTEs or visitors felt bored which showed on their face. On the contrary, many ISTEs succeeded in encouraging visitors in positive ways with resulting emotional values - e.g. happiness, enjoyment, and fun – which were also reflected on their faces including emotional values of ISTEs, which
could make visitors stay longer in social interaction with other visitors. The emotional values were identified in the groups of ISTE as follows.

- **Group 1 [Simple interaction with direct understanding]**
  Emotional values were found such as excitement, fun and surprise.

  The ‘Make fire’ exhibit illustrated in the following figure was one of the indoor exhibits at the Snibston Discovery Museum where the young visitors were excited because the fires were made by them. On the contrary, the exhibit might make other visitors fearful; those visitors who have a background of learning about danger of playing with fire from their families and their cultures.

  ![Figure 5.56: ‘Make fire’ exhibit](image)

- **Group 2 [Simple interaction with complex understanding]**, the emotional values such as being confused and bored were found more frequently than in group 1.

  For example, the ‘Magnetic forces – attraction and repulsion’ exhibit at the NSM in the following figure where the visitors might be curious about how magnets work. The exhibit shows only the interactions of magnets in nature, such that the visitors might learn at schools or themselves with ordinary magnets they could buy in a shop by experimenting. Some visitors might become bored because the exhibits were not transferring any scientific knowledge about the magnets to them. Also the exhibit did not excite and motivate visitors to interact with it. However, if some visitors have not seen magnets before, the exhibit might challenge the visitors and surprise them about the nature of magnets.
Figure 5.57: ‘Magnetic forces – attraction and repulsion’ exhibit

- **Group 3 [Multiple interactions with direct understanding]**

  Emotional values were found more in this group than in group 1 and 2, because most exhibits in this group involved the participation of a number of visitors together. These exhibits could make the visitors feel happy to interact with other people.

  The first example, the ‘Rolling Sticks’ exhibit in the following figure at the outdoor ‘Science Play’ area of the Snibston Discovery Museum involved children participating with the exhibit by themselves and/or with other new friends, and most children enjoyed it. However, it was possible that some exhibits might make the visitors bored, excited, and jealous at the same time. In some cases, the exhibits encourage the visitors to complete in a contest – e.g. the ‘Rolling Sticks’ exhibit where young visitors might race with other visitors because the exhibit provides two starting areas for rolling. Some young visitors might lose face from the competition if they do not win, they might express the unsuccessful feelings through their facial emotions such as being angry, bored, sad or shy. These unsuccessful emotions might have been learnt from their family and/or their cultures.

Figure 5.58: ‘Rolling Sticks’ exhibit
The second example, the ‘Power Vally’ exhibit at the Enginuity illustrated in the following figure gives several water machines which many young visitors may enjoy operating together - e.g. dam models, Archimedes Screw, and Hydroelectric power station - various features operated by pressing the buttons, turning a knob, and spinning a screw machine.

![Image of the 'Power Vally' exhibit]

Figure 5.59: ‘Power Vally’ exhibit

- **Group 4 [Multiple interactions with complex understanding]**
  The emotional values were found more than in group 1 such as being confused, bored. However, where the visitors discover the way to participate in the exhibit, they might feel more happiness and pride than with exhibits in group 1-3 when one visitor won by defeating all the other visitors. This is because most exhibits in group 4 can be harder to understand than other groups and the exhibits in group 4 allowed many visitors to participate together.

In the ‘Would you trust a robot to look after your child?’ exhibit at the Science Museum in London in the following figure, eight visitors could interact around a circle shaped table. Most visitors were interested by the many questions about the robot, projected on the table of the exhibit.
Age issues

Age must be considered, and particularly the restrictions of capability of young children and older people, when developing any suitable ISTEs. These people might have physical weakness, unsteady balance, and ill health of one sort or another. They also need to be careful what they are doing and bear in mind they are not strong enough for hard or laborious work. For instance, age might be linked to the background of education and level of visitors’ understanding. Museums could provide areas for children who have just started to learn the basics of science knowledge and have limited experience of science activities.

- **Group 1 [Simple interaction with direct understanding]**
  Influence of age was evident in some exhibits where they required inappropriately strong forces or inappropriate bending of the body while interacting with the exhibit.

  The first example, the ‘Bernoulli principle’ exhibit at the NSM in Thailand in the following figure was more suitable for children than old people. If a ball fell down to the floor many times, old people might need to pick up the ball by themselves frequently, which would not be safe practice for old people.
The second example, the ‘Would you suffer from Space Sickness?’ exhibit illustrated in the following figure at the National Space Centre, invites visitors to put their face into a big colour-dot bowl. They need to grasp two handles on both sides of this bowl. Then they press a button directly under the bowl, to rotate the colour-dot bowl. This exhibit might need to warn older visitors that using this exhibit may cause them to feel sick.

**Figure 5.62: ‘Would you suffer from Space Sickness?’ exhibit**

- **Group 2 [Simple interaction with complex understanding]**
  Age issues were evident in some exhibits in group 2 where some parts of exhibits were too sharp for safe handling.

  For example, the ‘Geometry – measuring angles’ exhibit in the following figure at the NSM has a metal telescope which might be dangerous for children who were not careful when using the exhibit. Also old people and pregnant women might need a chair to sit down to
use the exhibit because these people could look through the metal tube more easily when they were sat down at an appropriate level in the chair.

Figure 5.63: ‘Geometry – measuring angles’ exhibit

- **Group 3 [Multiple interactions with direct understanding]**
  Age issues were evident as an issue in some exhibits where inappropriately strong forces or inappropriate bending of the body was required while interacting with the exhibit.

  The first example, the ‘Centrifuge’ exhibit in the following figure at the NSM was not appropriate for old people and pregnant ladies because it required visitors to sit down and rotate in the chair.

  Figure 5.64: ‘Centrifuge’ exhibit

  The second example, the ‘Norgren Climbing Challenge’ exhibit illustrated in the following figure at the Enginuity where the exhibit can be used by a maximum of three visitors with one visitor pressing the button on each console - e.g. ‘Retract’, ‘Top Grip’, ‘Extend’ and ‘Bottom Grip’ to operate their mechanical object gripping on each rail.
The visitors should learn by practising their finger-skills by themselves, for operating the mechanical object to the top and the bottom of the rail about a height of 4 metres. Only one console on the left hand-side does not have the button ‘Top Grip’. The ‘Norgren’ is a sponsor to support this robotic control on this exhibit (Norgren, 2014). However, young and old visitors might get neck pain due to having to turn their face up-down in order to look at each climbing mechanical object, when he/she has to operate this exhibit for a long time without a comfortable seat to sit on.

Figure 5.65: ‘Norgren Climbing Challenge’ exhibit

- **Group 4 [Multiple interactions with complex understanding]**
  Age issues were evident as an issue in some exhibits where inappropriately strong forces were required to control the exhibit.

  In the first example, the ‘Human power’ exhibit at the NSM in the following figure, the visitor needed to rotate a handle. Electromagnetism could be generated by the visitor rotating the handle of a dynamo. A little train was powered by this electromagnetism. The speed of the train was dependent on the speed of rotation of the handle by the visitor. This exhibit was too
demanding for old and young people who could provide less force than teenagers and adults. Visitors needed to press a button to return this train to its starting point.

![Figure 5.66: 'Human power' exhibit](image1)

The second example, the ‘Natural Forces’ exhibit at the Woolsthorpe Manor illustrated in the following figure, provides the visitor with a wheel to spin. They must throw two beanbags one each into an inner and an outer wheel. In order to know how to do this experiment, the visitors need to read information on the 4 rotating-information panels located under the graphic panel on the right-hand side of the exhibit. However, the turning wheel is quite big and requires considerable force to spin it; this is a problem for older and younger visitors.

![Figure 5.67: 'Natural Forces' exhibit](image2)
**Disabled people**

Disabled people might require specialist volunteers who have been provided with relevant training by museums for these groups of visitors. In addition, autistic people who have learning problems, being slow to make progress - might be allocated to this disabled group. The parents and schools should accept that the speed and depth of learning of these groups using the ISTEs may well be less than visitors who have no such disabilities.

On the contrary, most ISTEs in Thailand did not offer any services to help disabled visitors. If any disabled visitors came from the UK and the USA, they might not find many facilities for disabled people in other countries. The science educators and designers should create the interactive science exhibits for supporting this group in terms of taking account of international culture. The exhibits were investigated for their provision for disabled people in the following groups.

- **Group 1 [Simple interaction with direct understanding]**

  There were only a few optional features for disabled people in the exhibits - e.g. Braille alphabets and audio aids were not provided.

  The first example, the ‘Pythagoras–father of geometry’ exhibit in the following figure at the NSM was built with many hexagonal nuts around its discs. Blind people might be able to touch these nuts but they could not see the liquid’s movement inside the exhibit.

  ![Figure 5.68: ‘Pythagoras–father of geometry’ exhibit](image)

The second example, the ‘A visit to Dishley’ exhibit at the Charnwood museum illustrated in the following figure, in which the visitor lifts any
handset and then presses the buttons to create the sound in the handset - e.g. start, increase volume, and reduce volume - to listen to the story of Robert Bakewell's farming in the 1780's. This exhibit involves farming technology rather than any science subject. It also provides the graphic information in English and Braille characters for blind people. However, it is possible that the museum could offer more features for blind people - e.g. they can touch small sizes of the embossed images duplicated from the original portrait of Robert Bakewell and his farming pictures as above in this exhibit.

Figure 5.69: ‘A visit to Dishley’ exhibit

- **Group 2 [Simple interaction with complex understanding]**
  
  No optional features for the disabled people were found as in group 1.

  For example, the ‘How far? - measuring distance’ exhibit at the NSM in Thailand in the following figure had only a normal map, when blind people needed an embossed map to touch.

Figure 5.70: ‘How far? - measuring distance’ exhibit
o **Group 3 [Multiple interactions with direct understanding]**

No optional features for the disabled people were found as in group 1 and group 2.

The first example, the two dishes of the ‘Speaking dish’ exhibit at the NSM in the following figure were built with four steps on the stairs in each dish. The visitor could speak using a speaking dish and could listen to another voice coming from an opposite dish. The example of the two ‘Speaking dish’ exhibits was not suitable for disabled visitors who had to use wheel chairs, because the two ‘Speaking dish’ exhibits had not been built with ramps to provide access for wheelchairs.

![Figure 5.71: ‘Speaking dishes’ exhibit](image)

The second example was the ‘Moth detector’ exhibit at the Thinktank (see the following figure) in which one visitor looks through a bat mask and closes his/her eyes. The visitor holds two handles on either side of the mask, which can be moved around to facilitate detecting the moths and listen for moths striking the visitor. They press a red button on the right-hand side of the bat mask and the screen will display how many moths that visitor has caught. This exhibit might not be suitable for people who have a hearing problem. Also blind people cannot see the number of moths displayed visually on the screen. It is possible that this exhibit can be adapted so a blind person could hear the numbers of moths displayed aurally through the speakers inside the bat mask after he/she completes pressing the red button.
Group 4 [Multiple interactions with complex understanding]

No optional features for the disabled people were found in some exhibits as in all the other groups.

For example, the ‘Lenses’ exhibit in the following figure at the NSM was not appropriate for blind people because they could not see the light rays through the three lenses. The exhibit needed to be developed with an embossed image of the light rays so blind people could be communicated with by their sense of touch.

Gender issues

The gender issues were complicated by the cultural issues. There are different life styles between men and women in each country where there were different social structures and different cultural behaviour such as hair styles, names, costumes, occupations, foods, drinks and sports. Some
cultures recognised men and women in similar situations in society such as a top position in offices, extreme sports. As a result, men and women could do many things and use the same actions. For example, Thai girls had an opportunity for operating the exhibits at the NSM but where considerable force was required this limited their ability to use those exhibits. Hence, Thai parents might feel unhappy, if their daughters interacted with some exhibits in the same way as males. This attitude comes from Thai traditional culture particularly where families are very socially conservative. However, most ISTEs should be designed to support both genders of visitors.

- **Group 1 [Simple interaction with direct understanding]**
  Gender issues were found in some exhibits in group 1 such as inappropriate features of the exhibit affecting the ability of women visitors to use the exhibit. There may be an overlap between gender issues and social issues.

  For example, a woman who wore a loose collared shirt and who needed to bend down for watching; touching or smelling the objects in the boxes of ‘What is this material?’ exhibit in the following figure at the Science Museum in London may create an immodest situation. This exhibit might interact with more than one visitor. However, only one visitor could participate because there was only one box.

  ![Figure 5.74: ‘What is this material?’ exhibit](image)

- **Group 2 [Simple interaction with complex understanding]**
  Gender issues were found as in group 1 - e.g. a small number of the
exhibits required actions which needed too great a force for ladies to control the exhibit.

For example, the ‘Electromagnets’ exhibit in the following figure at the NSM where the visitors needed to exert a force to rotate a plate of magnetic material – it was very tight and needed a great force to operate it.

![Figure 5.75: ‘Electromagnets’ exhibit](image)

- **Group 3 [Multiple interactions with direct understanding]**
  Gender issues were found in this group e.g. the exhibit might be unsuitable for a group of girls or women who were wearing a short skirt and a loose collared shirt.

  For example, the ‘Down the slippery slope’ exhibit in the following figure at the NSM where the female visitors rotated a platform to create varying slopes, on which four different surfaces presented different coefficients of friction. Slopes involved lifting the platform which was creating steep. Objects were placed on the four surfaces and the platform was rotated until a sufficiently steep slope was achieved and the objects slide down the slope. There are other hazards e.g. if the slope is left in a certain position, it can present an obstacle to other visitors walking behind the exhibit. They can trip over this obstacle.
Figure 5.76: ‘Down the slippery slope’ exhibit

- **Group 4 [Multiple interactions with complex understanding]**
  Gender issues were found in this group e.g. the exhibit might be unsuitable for the group of girls and women who wear a short skirt and some exhibits were too hard for controlling.

  For example, the ‘Spin the coil – generate electricity’ exhibit in the following figure at the NSM where for any woman wearing a short skirt and participating with other visitors, her underwear may be seen by others. In such a case, the exhibit was not properly designed for all women in certain cultures such as the Thai culture.

Figure 5.77: ‘Spin the coil – generate electricity’ exhibit

However, any one of the ISTEs might be affected by various cultural issues e.g. the ‘Spin the coil – generate electricity’ exhibit in group 4 at the NSM in Thailand where there was overlapping of social issues, disabled people issues, and gender issues.
5.5.3 Phase 3: Overview of the online questionnaire

Initially, the results from the questionnaire were investigated. The eight main results of the online survey were addressed as follows.

[1] Number of various groups in the positions

The 121 results came from the 66 male and 55 female respondents of science museums around the world as shown in the following table.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Male</th>
<th>Female</th>
<th>A number of results (persons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director</td>
<td>19</td>
<td>9</td>
<td>28</td>
</tr>
<tr>
<td>Designer</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Educator</td>
<td>9</td>
<td>17</td>
<td>26</td>
</tr>
<tr>
<td>Exhibitor</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Researcher</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Curator</td>
<td>7</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Volunteer</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Others</td>
<td>24</td>
<td>16</td>
<td>40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>66</td>
<td>55</td>
<td>121</td>
</tr>
</tbody>
</table>

Table 5.4: Groups of the positions and a number of results

The 40 results from ‘other’ positions were from various occupations such as exhibit projects manager, creative director, exhibition manager, expert, exhibit developer, head of the science centre, interpretation assistant, project director/exhibits and programs, science communicator, science show and exhibit design consultant, etc.

[2] Number distribution of the museums

In accordance with the online survey, there were a small number of experts who worked at the same museums and their results are reported. For example, three respondents worked at the National Museum of Natural Science in Taiwan - a curator, a researcher, and a volunteer. There were 121 responses to the online questionnaire provided by many experts from 109 global science museums/ institutes.

The number of the respondents from the museums are shown in the main eight regions of Murdock’s (1983) Outline of World Cultures in the following table.
Murdock’s (1983) world culture regions | Number distribution of the museums
---|---
(1) Africa | 4
(2) Asia | 10
(3) Europe | 33
(4) Middle East | 2
(5) North America | 43
(6) Oceania | 6
(7) Russia | 1
(8) South America | 10
Total | 109

**Table 5.5: The 8 main areas of geographical world regions**

Adopting the United Nations’ (2009) major areas and regions of the world, the number of the target museums in the main six regions of the United Nations (2009) is shown in following table.

| The United Nations’ (2009) major regions | Number of the target museum |
---|---|
(1) Africa | 4 |
(2) Asia | 12 |
(3) Europe | 34 |
(4) Latin America and the Caribbean | 11 |
(5) Northern America | 43 |
(6) Oceania | 5 |
Total | 109 |

**Table 5.6: The 6 main areas of geographical world regions**

[3] **Number distribution of the countries**

The respondents of the online survey from the 109 global museums were re-examined to identify the number in each country. Some respondents of the museums in the UK stated their countries as Scotland and Northern Ireland, but in this study they have been merged into the UK. In addition, the museums in Macao and Taiwan have been included as part of China. The online survey was completed by 121 experts from 37 countries.

The number in each of the respondents’ countries is shown in the eight main regions of Murdock’s (1983) Outline of World Cultures in the following table.
A number of the target list of the countries

<table>
<thead>
<tr>
<th>Murdock’s (1983) world culture regions</th>
<th>A number of the target list of the countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Africa</td>
<td>3</td>
</tr>
<tr>
<td>(2) Asia</td>
<td>6</td>
</tr>
<tr>
<td>(3) Europe</td>
<td>15</td>
</tr>
<tr>
<td>(4) Middle East</td>
<td>2</td>
</tr>
<tr>
<td>(5) North America</td>
<td>3</td>
</tr>
<tr>
<td>(6) Oceania</td>
<td>2</td>
</tr>
<tr>
<td>(7) Russia</td>
<td>1</td>
</tr>
<tr>
<td>(8) South America</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>37</td>
</tr>
</tbody>
</table>

**Table 5.7: The 8 main areas of geographical world regions**

Adopting the United Nations’ (2009) major areas and regions of the world, the number of the respondents of the target countries are shown in the main six regions of the United Nations (2009) in the following table.

<table>
<thead>
<tr>
<th>The United Nations’ (2009) major regions</th>
<th>A number of the target list of the countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Africa</td>
<td>3</td>
</tr>
<tr>
<td>(2) Asia</td>
<td>8</td>
</tr>
<tr>
<td>(3) Europe</td>
<td>16</td>
</tr>
<tr>
<td>(4) Latin America and the Caribbean</td>
<td>6</td>
</tr>
<tr>
<td>(5) Northern America</td>
<td>2</td>
</tr>
<tr>
<td>(6) Oceania</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>37</td>
</tr>
</tbody>
</table>

**Table 5.8: The 6 main areas of geographical world regions**

The age ranges relating to the respondents are shown in the table below. The results showed that the respondents who are museum staff from the many countries had age ranges between 20 and over 80 years old. Most staff were in the age range of 30-39 years old with female staff more numerous than male staff. Only one member of staff was over 80 years old and works in the position of ‘science show and exhibit design consultant’ at the NSM in Thailand.
Age ranges (years old) | Male (persons) | Female (persons) | A number of the respondents (persons)
--- | --- | --- | ---
19 and Under | 0 | 0 | 0
20-29 | 7 | 5 | 12
30-39 | 15 | 22 | 37
40-49 | 20 | 12 | 32
50-59 | 10 | 9 | 19
60-69 | 12 | 7 | 19
70-79 | 1 | 0 | 1
>80 | 1 | 0 | 1
Total | 66 | 55 | 121

Table 5.9: Age ranges and a number of respondents

[4] The number of the experts in each cultural region
The two largest cultural regions are North America and Europe, and between them they have more science museums than all other cultural regions. In these circumstances, it was expected that the largest number of the respondents was from these two cultural regions, as shown in the following table.

<table>
<thead>
<tr>
<th>Cultural regions</th>
<th>Male</th>
<th>Female</th>
<th>A number of the experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Africa</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>(2) Asia</td>
<td>9</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>(3) Europe</td>
<td>19</td>
<td>14</td>
<td>33</td>
</tr>
<tr>
<td>(4) Middle East</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(5) North America</td>
<td>25</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>(6) Oceania</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>(7) Russia</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(8) South America</td>
<td>5</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>66</td>
<td>55</td>
<td>121</td>
</tr>
</tbody>
</table>

Table 5.10: Number of respondents in each culture

[5] The attitude of the experts to the 10 dimensions of the cultural issues
From question number 19 in Appendix 10, 108 experts out of the 121 experts believe that there is more than one cultural influence on an interactive
science and technology exhibit (ISTE), as shown in the following figure. Additionally, the number of experts from North America which voted was more than experts from any other region. The online survey was sent to many experts in museums in North America where the numbers of museums of science are greater than any other region in the world.

![Graph showing cultural influence on ISTE](image)

Figure 5.78: 108 experts out of the 121 experts believe that there is more than one cultural influence on an ISTE

This is also shown in the table below.

<table>
<thead>
<tr>
<th>Cultural regions</th>
<th>A number of the experts believed</th>
<th>A number of the experts in the survey</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Africa</td>
<td>4</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>(2) Asia</td>
<td>12</td>
<td>13</td>
<td>92</td>
</tr>
<tr>
<td>(3) Europe</td>
<td>28</td>
<td>33</td>
<td>85</td>
</tr>
<tr>
<td>(4) Middle East</td>
<td>1</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>(5) North America</td>
<td>48</td>
<td>50</td>
<td>96</td>
</tr>
<tr>
<td>(6) Oceania</td>
<td>4</td>
<td>7</td>
<td>57</td>
</tr>
<tr>
<td>(7) Russia</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>(8) South America</td>
<td>11</td>
<td>11</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>108</strong></td>
<td><strong>121</strong></td>
<td><strong>89</strong></td>
</tr>
</tbody>
</table>

Table 5.11: Number of the experts believed more than one dimension of the cultural dimensions affects any of the examples of ISTEs
[6] The most important of the cultural issues

Based on the answers to question number 21 in Appendices 10, the most important cultural issues relating to the interactive science and technology exhibits are expressed in percentages, voted from the many experts around the world in order in the following table.

<table>
<thead>
<tr>
<th>The dimensions of the cultural issues</th>
<th>Percentages</th>
<th>A number of the experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Language issues</td>
<td>27.27 %</td>
<td>33</td>
</tr>
<tr>
<td>(2) Conceptual understanding</td>
<td>21.49 %</td>
<td>26</td>
</tr>
<tr>
<td>(3) Technologies issues</td>
<td>11.57 %</td>
<td>14</td>
</tr>
<tr>
<td>(4) Other issues</td>
<td>10.74 %</td>
<td>13</td>
</tr>
<tr>
<td>(5) Social issues</td>
<td>9.92 %</td>
<td>12</td>
</tr>
<tr>
<td>(6) Physical skills</td>
<td>4.96 %</td>
<td>6</td>
</tr>
<tr>
<td>(7) Gender issues</td>
<td>4.96 %</td>
<td>6</td>
</tr>
<tr>
<td>(8) Disable people</td>
<td>2.48 %</td>
<td>3</td>
</tr>
<tr>
<td>(9) Visual cultures</td>
<td>2.48 %</td>
<td>3</td>
</tr>
<tr>
<td>(10) Age issues</td>
<td>2.48 %</td>
<td>3</td>
</tr>
<tr>
<td>(11) Emotional values</td>
<td>1.65 %</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100 %</strong></td>
<td><strong>121</strong></td>
</tr>
</tbody>
</table>

Table 5.12: The most important cultural issues, in percentage

The most important of the 10 dimensions of the cultural issues were expected to be identified by the responses of the 121 experts from 37 countries. These 10 dimensions of the cultural issues were investigated to identify which one was believed to be the most important by all the respondents of the museums in this study.
<table>
<thead>
<tr>
<th>Cultural regions</th>
<th>Physical skills</th>
<th>Technologies issues</th>
<th>Language issues</th>
<th>Visual cultures</th>
<th>Conceptual understanding</th>
<th>Social issues</th>
<th>Emotional values</th>
<th>Age issues</th>
<th>Gender issues</th>
<th>Disabled people</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Africa</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(2) Asia</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>(3) Europe</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>(4) Middle East</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(5) North America</td>
<td>3</td>
<td>4</td>
<td>19</td>
<td>1</td>
<td>7</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>(6) Oceania</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(7) Russia</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>(8) South America</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>14</td>
<td>33</td>
<td>3</td>
<td>26</td>
<td>12</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 5.13: The single most important cultural issues in each cultural region

The most important cultural issues exhibited in various cultures (voted for by experts) are shown in the following figure.

![Figure 5.79: The most important cultural issues shows in various cultures](image)
For the answers to question number 21 in Appendices 10, ‘Which one is the most important cultural issue in your museum?’, a summary of the most important cultural issues as voted by the 121 experts in the 8 main cultural regions is as follows.

- Four experts from Africa voted that language issues and conceptual understanding were equally the most important.
- Asian experts believed that conceptual understanding and language issues were equally the most important.
- European experts concluded that conceptual understanding was the most important.
- Two experts from the Middle East voted that technologies issues and conceptual understanding were equally the most important.
- North American experts concluded that language issues were the most important.
- Oceania experts concluded that social issues were the most important.
- South American experts considered that conceptual understanding was the most important cultural issues.

The values in the ordered list of issues were based on the total number of votes that each dimension received across the whole sample. The ‘other issues’ category consisted of ‘all of the cultural issues’, ‘open-ended playfulness’ and ‘do not understand this question’.

[7] Other dimensions of the cultural issues

Table 5.11 reported other cultural issues which were suggested by 10.74% of the 121 experts such as:

- “Difference between speaking and writing language, e.g. Cantonese and Mandarin - confusion of the meaning of words” (no.58, O., Curator, Communications Museum of Macao, China).
- “Educational level? Do people think they belong in a science center or that they can think for themselves? (no.13, L.M., researcher, Arizona Science Center, USA).
- “Believing/non believing in God/religion is one issue which may influence visitors approach” (no.9, S.J.S., curator, Science City Kolkata, India).

- “Economic and social differences. Countryside people, who do not have usually access to cultural activities” (no.79. Virginia Puntigliano, Educator, Espacio Ciencia LATU, Uruguay).

- “Education, economic status, ethnic groups, partners they are with, people come with different expectations” (no.107. E.H., Director, Maloka, Colombia).

[8] Comparing the dimensions of the cultural issues through cross-cultures

One result came from the Russian science museum. Over all, the results were presented for the institutes in the eight cultural zones which have interactive science and technology exhibits (ISTEs) in Africa, Asia, Europe, Middle East, North America, Oceania, Russia and South America.

<table>
<thead>
<tr>
<th>Cultural regions</th>
<th>Physical skills</th>
<th>Technologies issues</th>
<th>Language issues</th>
<th>Visual cultures</th>
<th>Conceptual understanding</th>
<th>Social issues</th>
<th>Emotional values</th>
<th>Age issues</th>
<th>Gender issues</th>
<th>Disabled people</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Africa</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
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<td>4</td>
</tr>
<tr>
<td>(2) Asia</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>7</td>
<td>6</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>(3) Europe</td>
<td>22</td>
<td>21</td>
<td>31</td>
<td>22</td>
<td>23</td>
<td>23</td>
<td>26</td>
<td>22</td>
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<td>22</td>
</tr>
<tr>
<td>(4) Middle East</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>(5) North America</td>
<td>31</td>
<td>32</td>
<td>46</td>
<td>40</td>
<td>30</td>
<td>47</td>
<td>39</td>
<td>29</td>
<td>45</td>
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<tr>
<td>(7) Russia</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(8) South America</td>
<td>8</td>
<td>8</td>
<td>11</td>
<td>9</td>
<td>7</td>
<td>9</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 5.14: The 10 dimensions of the cultural issues which were believed to influence the use of interactive science exhibits
Table 5.14 was converted to Table 5.15 by calculating percentages - the numbers of the experts in each culture in the following figure shows that many experts who came from different cultures believed in all of these 10 dimensions. However, there was only one result from the Russian expert who believed in visual cultures.

<table>
<thead>
<tr>
<th>Cultural regions</th>
<th>Physical skills</th>
<th>Technologies issues</th>
<th>Language issues</th>
<th>Visual cultures</th>
<th>Conceptual understanding</th>
<th>Social issues</th>
<th>Emotional values</th>
<th>Age issues</th>
<th>Gender issues</th>
<th>Disabled people</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Africa</td>
<td>100</td>
<td>75.0</td>
<td>100.0</td>
<td>75.0</td>
<td>100.0</td>
<td>75.0</td>
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<td>69.2</td>
<td>53.9</td>
<td>53.9</td>
<td>53.9</td>
<td>61.5</td>
</tr>
<tr>
<td>(3) Europe</td>
<td>66.7</td>
<td>63.6</td>
<td>93.9</td>
<td>66.7</td>
<td>69.7</td>
<td>100.0</td>
<td>78.8</td>
<td>78.8</td>
<td>81.8</td>
<td>66.7</td>
</tr>
<tr>
<td>(4) Middle East</td>
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<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>50.0</td>
</tr>
<tr>
<td>(5) North America</td>
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<td>92.0</td>
<td>80.0</td>
<td>60.0</td>
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<td>78.0</td>
<td>78.0</td>
<td>90.0</td>
<td>82.0</td>
</tr>
<tr>
<td>(6) Oceania</td>
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<td>85.7</td>
<td>100.0</td>
<td>71.4</td>
<td>100</td>
<td>71.4</td>
<td>71.4</td>
<td>85.7</td>
<td>85.7</td>
</tr>
<tr>
<td>(7) Russia</td>
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<td>0.0</td>
<td>100.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>(8) South America</td>
<td>72.7</td>
<td>72.7</td>
<td>100.0</td>
<td>81.8</td>
<td>63.6</td>
<td>81.8</td>
<td>45.5</td>
<td>45.5</td>
<td>72.7</td>
<td>72.7</td>
</tr>
</tbody>
</table>

Table 5.15: The 10 dimensions of the cultural issues which were believed to influence the use of interactive science exhibits in term of percentages of the experts in each culture

5.6 Discussions

5.6.1 Phase 1: The 10 dimensions of cultural issues relating to interaction design

Four new cultural dimensions were found in the results. These new dimensions in this study relate to the cultural models of other researchers in the literature review - e.g. Hall (1959), Hall and Hall (1990), Hofstede (2001), Trompenaars (1993), Trompenaars and Hampden-Turner (1997), and Victor (1992) - which were identified as follows.
Technology issues relating to the dimension, as in parts of the ‘Environment and technology’ in Victor’s (1992) cultural models.

Language issues relating to the dimension are parts of the ‘Language’ in Victor’s (1992) cultural models and the ‘Speed of messages’, ‘context’ in Hall’s (1959) cultural models and ‘Information flow’ in Hall and Hall’s (1990) cultural models.

Social issues relating to the dimension are parts of the ‘Action chains’ in Hall and Hall’s (1990) cultural models.

Emotional values relating to the dimension are parts of the ‘Neutral or emotional’ in Trompenaars’ (1993) and Trompenaars and Hampden-Turner’s (1997) cultural model.

Disabled people issues relating to the dimension are parts of the ‘Non-verbal behaviour’ in Victor’s (1992) cultural model.

Gender issues relating to the dimension are parts of the ‘Masculinity vs. femininity’ in Hofstede’s (2001) cultural models and ‘Social organisation’ in Victor’s (1992) cultural model.

Additionally, it was noted that cultural issues relating to conceptual understanding consist of two main contexts – ‘conceptions of interaction design’ and ‘conceptions of scientific knowledge’.

However, the four dimensions of the cultural issues in this chapter – ‘physical skills’, ‘visual cultures’, ‘conceptual understanding’, and ‘age issues’ - are not mentioned precisely in the cultural models of the researchers above.

5.6.2 Phase 2: Validation of the 10 dimensions of cultural issues relating to ISTEs at the museums of science

The interactive science exhibits in traditional styles which were examined were made of simple mechanical tools and general electronic devices. Examples of these devices are pulleys, gears, push-buttons, cog belts, light bulbs, and motors. Modern ISTEs comprise advanced electronic devices.
such as computer touch screens, digital projectors, webcams or video cameras, mouse, track balls, microphones, and speakers. Nevertheless, both mechanical and electronic types of ISTE can fall into one of the 4 groups of the new classification. Additionally, Marcus’s (2006) perspective, with regard to culture and interaction designs, stated most ISTEs in the world were designed for science education and were developed within the national cultural structures.

A neutral term ‘cultural issues’ was used to deal with the cultural matters rather than using the terms ‘cultural similarities’ or ‘cultural differences’. The validation of the new classification considers the 10 dimensions of cultural issues relating to ISTEs at the museums of science as follows.

[1] Physical skills
Several ISTEs in all groups of the new classification were always found to include Mark’s (1996) viewpoint of turn it on and off for manual operation. This interaction ‘turn it on and off’ may come from the visitors’ experience which occurred as a common interaction in daily life and visitors also need to know what appearances of a specific switch can provide them with ‘turn it on and off’ indications. The recommendation of Allen (2004), and Allen and Gutwill (2004) about uncommon cultural design - e.g. rotating a knob clockwise to undo something - influences visitors’ understanding of the interaction through ISTEs by their cultural experiences. This uncommon cultural design may found in ISTEs in all groups, if the exhibit’s design is not concerned about the operating features. For example, young children used to lay down a black paddle in the ‘A New World’ exhibit at the Woolsthorpe Manor rather than moving it in the vertical way and this meant the sensor of this exhibit could not detect the black paddle’s movement.

The viewpoint of Edwards and Lees (1974), Bainbridge (1983), and Roussou and Efraimoglou (1999) about easy-to-learn interfaces using the ‘press a button’ was found in group 1 and 2 of the new ISTEs’ classification relating to using the kiosks and computer. But ISTEs in group 3 and 4 may occasionally offer complex rather than routine interaction as Rasmussen and Vicente (1989) recommended. For example, visitors should use both hands to turn
three knobs on the ‘Gears and how they work’ exhibit at the NSM and compare the weights. This example is similar to ‘asymmetry interaction’ of both hand skills as Singh et al.’s (2001) research recommendations. On the other hand, visitors might need to be trained or have clear explanations provided by the museum staff, if ISTEs’ operations required unusual physical skills; the training could provide the necessary experience as Bainbridge’s (1983) viewpoint. However, it is possible that ISTEs should be designed to reduce the complexity of the tasks to ensure visitors understand what level of physical skills they need to interact with ISTEs in as easy a way as possible.

Additionally, ISTEs at the research museums may impact on left-handers as in McManus’s (2003) viewpoint of left-handed devices, because ISTEs in all groups of the new classification were designed to use particular hand skills. On the other hand, if any ISTE always required visitors to use one of their hands only rather than the other hand, this may cause some visitors who are left or right-handers to be uncomfortable in their interaction with that ISTE. For example, the ‘A New World’ exhibit at the Woolsthorpe Manor might require left and not right-handed use because a sensor to detect movement is located on the right-hand of ISTEs.

**[2] Technologies issues**

Some ISTEs at the research museums might not install any technological components in all the four groups of the new ISTEs’ classification for some reason. For example, the museums could reduce the energy cost for using electronic devices. Conveniently, some exhibits were developed as travelling exhibits where the staff of the museums could transport their ISTEs to a location without electricity. Only a few exhibits showed the motor and dynamo in order to demonstrate how they worked or the designers might display the shaped structure of the motor and dynamo. Out-door exhibits at the Thinktank use electricity more than those at Snibston museum.

At present, most ISTEs at all the research museums currently provide real interactions with visitor(s) rather than virtual interactions accessed through their personal digital assistant (PDA) devices e.g. mobile phone, tablet, and digital smart watches. However, these PDA devices are new technological
items which do not appear in the technological list in 1959 of the Hughes’ (2005) report. These PDA devices can be used to access digital information on the internet and networks such as Sato and Chen’s (2008) recommendation. On the other hand, it is possible that in the future several science museums will support visitors using PDA devices to access more information regarding ISTEs - e.g. images, video and multimedia as Othman et al.’s (2011) suggestion. On the contrary, visitors might essentially need several real interactions e.g. pressing, turning, riding, throwing, and smelling - through visitors’ experience rather than access via digital devices - e.g. touching, waving, listening, and sliding on touch screen - as Norman's (2000) viewpoint for learning by ‘doing' with technology concepts. On the other hand, it may be assumed that the basis of ISTEs at the research museums in the UK being a developed country may involve these factors - culture, interaction design, and technologies issues - similar concepts of the report from John Thomas of IBM by Chittaro (2008). However, the use of ISTEs by visitors also involves a connection between culture and technology as the viewpoint of Sieffert (2006) for transferring knowledge of technological designs through to the next generations.

Some ISTEs at research museums were found as hybrid exhibits involving digital equipment and traditional object exhibits as described by Hornecker and Buur (2006) such as:

- The ‘Addition - how fast are you?’ exhibit at the NSM using an abacus and digital numbers on a screen
- The ‘Scan it’ exhibit at the ‘Enginuity’- which uses a remote pointer in many traditional and modern devices - e.g. wind pump, bicycle and jet-engines.

These hybrid exhibits can be designed in all groups of the new classification and may help visitors to learn and recognise these vintage devices.

Furthermore, ISTEs may be found with 3D virtual environment (3DVE) in any museum in the future as in the report of Wyeld et al. (2006) which stated that design to support both simple and multiple interactions in any groups of the new ISTEs’ classification could be used to encourage visitors in virtual role-play activities.
Human Computer Interaction (HCI)

Computer interaction with visitors was found in some exhibits relating to all four groups of the new ISTEs’ classification. However, HCI might be investigated relating to social interaction. Several interactive exhibits in groups 3 and 4 [multiple interactions] had supported groups of visitors’ participation in social learning more than in groups 1 and 2 [simple interaction].

Various devices supporting HCI were designed using multimedia interactivity technology - e.g. plasma screen display – and can provide scientific experience for groups of visitors rather than individual people (DiPaola and Akai, 2006), e-learning content (Buzatto et al., 2009), and gesture display technology (Rehm et al., 2008). They were found in many research museums such as the Science Museum in London, the Thinktank, the National Space Centre, the Enginuity and the NSM. All such designs can be found in groups 1, 2, 3, and 4 of the new ISTEs’ classification. Nevertheless, these research museums have used different technological devices - e.g. track-ball, mouse, touch-screen, gesture recognition capturing hand and body movement for their visitors’ interaction.

User-Centred Design (UCD)

UCD lays great importance on supporting visitors by means of technology in the interface. However, UCD is also an essential facility relating to all groups of the new ISTEs’ classification which involves individual users (one visitor per ISTEs) as well as group users (several visitors per exhibit), similar to Gulliksen et al.’s (2003) definition of ‘User-Centred System Design (UCSD)’.

At present, several research museums may not be concerned about designing ISTEs using UCD from various cultural backgrounds e.g. physical skills, gender issues, and disabled people.

UCD relating to ISTEs at the research museums affect several patterns of visitors’ behaviour in the real world - e.g. interacting, discovering, and using social communications. This is similar to Segerståhl and Jokela’s (2006) viewpoint of interaction patterns on the website as part of the digital world - e.g. navigation, searching, and using graphics – which can be used to
analyse UCD. However, ISTEs in any science museums should consider Jokela et al.’s (2003) report of ISO 9241-11 and ISO 13407 relating to the guidance for user-centred design. The topic of UCD is discussed in the two subset areas of User Interface Design (UI) and Cultural User Interface (CUI) as follows.

- **User Interface Design (UI)**

  User Interface Design (UI) was an important consideration for ISTEs in all groups of the new classification. At present, virtual interactions on the internet have been adopted when developing user interface (UI) design, such as 3D games, avatar, and 3D applications. If these technologies relating to UI provide various advantages, similar to those virtual interactions in the real world, the virtual interactions on the internet might develop in the same way as the real exhibit. The visitors could interact with the virtual exhibit like a real interaction. An example is the ‘Would you trust a robot to look after your child?’ exhibit at the Science Museum in London which eight visitors interact by touching on the circle table of this exhibit. It may be designed to be close to the virtual idea of tangible interaction design and tangible user interfaces (TUIs) as Hornecker and Buur’s (2006) viewpoint providing face-to-face social interaction rather than digital social interaction.

  On the other hand, human-computer interaction (HCI) may occur in a disrupted real-world system where McFarlane and Latorella’s (2002) recommendation that such multi-tasking environments would need powerful user-interface designs to support the people using them. These considerations should be taken into account in the ISTEs in all groups of the new classification. Disruption might frequently be found in group 3 [multiple interactions with direct understanding] and group 4 [multiple interactions with complex understanding] which involve many visitors operating ISTEs. Additionally, an ecological interface design (EID) should follow design guidelines for support multitasking of three levels of cognitive control-‘knowledge-based’, ‘rule-based’ and ‘skill based’ - as Rasmussen and Vicente’s (1989) suggestion. Multitask-activities were occasionally found in
group 4 rather than the other groups because it involved more scientific knowledge such as using computers to operate a microscope.

The author of this thesis believes that it is possible that the designers of ISTEs may share ideas between several museums to develop software for exploring cultural analysis using video observations of visitors using their ISTEs. The benefits of having this user-centred design described by Gulliksen et al. (1999) would be realised by using this method.

- **Cultural User Interface (CUI)**

At present, cultural user interfaces of ISTEs appear on the real physical exhibits rather than digital versions on screen monitor and projector - e.g. house model, wind turbine, and bicycle model – where visitors can recognise these objects are part of their local culture. ISTEs at the research museums in all groups of the new classifications may not be accessible on the internet as per Kirigin’s (2005) recommendation for an enquiry service through the website for non-Western people. However, it is possible that several science museums in the future may offer visitors the facility to access their ISTEs on any mobile-internet access device - e.g. mobile phone, tablet, laptop, and etc. – in line with a user friendly CUI for visitors, as in the viewpoint of Oh et al. (2011). On the other hand, museums can offer an optional CUI on the internet for overseas visitors through the museums’ websites e.g. translating the language on the graphic panels of ISTE into the first languages of visitors as the options for word-processing as in Clemmensen’s (2010) perspective, or showing pictures of timelines in vertically the same position as in China and Japan as Schaefer’s (2011) viewpoint. Furthermore, the CUI of ISTEs in any science museums can be designed in terms of 3D interactive environments as per Celentano and Pittarello’s (2001) idea and they can provide the flexibility of cross-cultural interfaces for several countries as Human Factors International’s (2012) recommendation. However, not all the research museums may currently offer these options.

[3] **Language issues**

Language which humans created and developed was for the purpose of communication - e.g. sounds, signs, and written symbols (Crystal, 1987) and
social interaction through language (Trager, 1949). This appeared on and around ISTEs in all the research museums. Not only could the language be applied in reading and speaking in daily life, but it has also been used to transfer ideas from one person to other people using symbols and signals. Investigating the examples in these exhibits, it was revealed that many scientific words created language issues which were similar in all groups of the new ISTEs’ classification. Although the words – e.g. power, gravity, geometry, radiation, and cell - do directly translate into other languages which the ISTEs were established. These scientific words were still new vocabularies and uncommon words in other languages similar to the idea of Hofstede (2001) who pointed out that several words in English may not exactly translate in other languages.

Language and culture are closely related as Holtgraves and Kashima’s (2008) viewpoint which may significantly affect visitors’ learning from ISTEs. Some languages such as Thai often did not use scientific words before scientific exhibits introduced these terms to Thailand. Schaefer (2011) describes the special features of other languages such as Chinese, Japanese and Korean which is that they can be written top down – this style is not normally found in ISTEs in the UK and Thailand. Grammenos et al.’s (2011) recommendation was to support other languages, by providing a selection of language choices for tourists. Nevertheless, several kiosks and touch screen media of the research museums in the UK do not support multiple- languages. On the contrary, all ISTEs at the NSM present Thai and English as following Lewis’s (2000) perspective of multi languages on displays and using international characters on the displays as Keller et al.’s (2006) viewpoint. However, some words such as plasma, nuclear, fossil, fluidised bed, and hyperbola were ‘transferred’ to Thai as transliterations – with the Thai words borrowed exactly from the English language. Thai people could not understand these transliterations. The exhibits needed to clarify these words by a definition on their graphic panels. Also, language in all groups of the new ISTEs’ classification may need to be considered in the use of language in the kiosks’ display, the same as Van Welie and Van der Veer's (2003) viewpoints in relation to websites.

Visual cultures were found at the target museums in ISTEs in all four groups of the new classification. The terms - signs, objects and equipment of Marcus’s (2006) visual cultures which were required in representing scientific knowledge were evident. e.g. several steps of the interaction process illustrated by the ISTEs appeared on the graphic panel showing diagrams, symbols, and figures – these may appear in group 3 [Multiple interaction with direct understanding] and group 4 [Multiple interaction with complex understanding] rather than in groups 1 and 2. Also the shape of ISTEs that occur in everyday life may affect visitors’ understanding of what ISTEs are about and what visitor’s responses are required for interaction such as a hand shape and a cooking-pan shape.

The use of an inappropriate symbol in the ISTEs might cause the visitors to misunderstand the concept of ISTEs - e.g. a fire figure and a red palm shape - this can mean something harmful in some cultures. In Thailand, these images would consistently convey the message ‘Danger’ - the effect of such an image as suggested by Düttmann (2002) and Keifer-Boyd et al. (2003). These symbols may promote fear by visitors of interaction with ISTEs. On the other hand, ISTEs should clearly describe visual cultures where visitors may not recognise the meaning of the symbols – in which case, ISTEs need to develop and use traditional symbols known to visitors. Furthermore, the size of the main operating console and controls in ISTEs should be clearly designed so visitors can easily and accurately operate ISTEs - e.g. appropriate sizes of buttons were found in all four groups – as per the recommendation of Allen and Gutwill (2004) using a large dial rather than a small knob. In addition, the viewpoints of Weinschenk (2011) and Schaefer (2011) about colour in visual cultures have been adapted by most of the target museums using dark colours for ISTEs rather than vivid colours. However, some museums - e.g. Snibston Discovery Museum, Thinktank, and Enginuity - frequently use bright colours on their ISTEs, unlike other museums. This may be more effective for attracting children.
[5] Conceptual understanding

‘Conceptual understanding’ of interactive science and technology exhibits may involve two main areas - which are scientific and technological concepts of ISTEs and the design concepts relating to the term ‘interaction design’ of ISTEs. From the literature review, Marek et al.’s (2002) research on science and technology concepts - conceptual understandings and cognitive developmental levels – is not useful as their consideration was not concerned with cultural differences between local and international visitors. This limits the relevance to this broader thesis.

The concepts behind ISTEs’ interaction design were described by Allen and Gutwill’s (2004) who reported five main problems encountered in interaction with interactive science exhibits. These were as follows:

- (1) **Multiple functions** were found in group 3 [Multiple interactions with direct understanding] and group 4 [Multiple interactions with complex understanding] of the new ISTEs’ classification, rather than group 1 [Simple interaction with direct understanding] and group 2 [Simple interaction with complex understanding]. Examples of age issues are: the ‘Norgren Climbing Challenge’ exhibit in group 3 at the Enginuity which visitors press several buttons to control the three mechanical objects moving up and down, and the ‘Natural Forces’ exhibit in group 4 at Woolsthorpe Manor – which provides visitors with several interactions such as spinning a large wheel and throwing a sand bag into it.

- (2) **Multiple features** occurred at several target museums in groups 2, 3 and 4 rather than group 1 – e.g. in relation to visual cultures, the ‘Sound waves and musical notes’ exhibit in group 4 at the NSM where visitors can play any songs they like on a huge musical keyboard. However, it is possible that ISTEs in group 1 can be designed with ‘multiple features’ (wider possibilities) - e.g. the ‘Block Printing’ exhibit at the Snibston Discovery Museum where visitors can stamp various patterns on paper.
(3) **Open large scale options** which might disrupt other visitors were found in groups 3 and 4 rather than groups 1 and 2. However, if ISTE s in groups 1 and 2 were designed to be on a large scale this can disturb other visitors. For example the ‘Scan it’ exhibit at ‘Enginuity’ in group 1 of technologies issues - where some visitors want to scan an object, but other visitors may obscure those objects when they look at them.

(4) It may be difficult to determine which visitors need to have **background knowledge** when considering interactive options. This common problem is found in all of the four groups of ISTE s especially those which involve technology and complex science and ISTE s that could not create the interaction clearly using the visitors’ senses. An example is the ‘Optical fibres’ exhibit at the NSM (which has language issues and falls into group 4 of the classification) – visitors may see the light through a small tube and they might not know what is useful information. This exhibit should provide graphic diagrams and information on the scientific concept for use by visitors.

(5) **Secondary functions** could undermine the primary functions and this can be found in all groups of ISTE s, if the designer did not understand the ISTE s had to be suitable for social interaction. For example, the ‘Addition - how fast are you?’ exhibit at the NSM in social issues in group 2. A visitor may come along and prefer to operate an abacus rather than use a segment display to set numbers for adding, and to compete with another visitor who did use a calculator.

In terms of the conceptual understanding relating to technology, Rasmussen and Vicente (1989) pointed out the significance of technology error to human-system interaction. Technology issues overlapped with conceptual understanding and this could be found in terms of errors in all four groups of ISTE s. An example is technologies in Human Computer Interaction (HCI) in group 4 where visitors may not know how to use their hand - waving it in the air to zoom in and zoom out of the virtual earth on the ‘Exploring the climate system’ exhibit at the Science Museum in London. This may affect visitors
who do not understand the virtual earth because of their errors of interaction on the computer screen. Furthermore, Allen and Gutwill (2004) suggested the three most common interactive features were - PAR – ‘Physical’, ‘Adjustable’, and ‘Relevant’, this was reported in the literature review. These terms were found in all groups of ISTEs. For example, visitors interacting with the ‘Plasma ball’ exhibit at the NSM in ‘Physical’ using activities such as touching, watching, and the exhibit can be ‘Adjustable’ by moving their hands around the plasma sphere. In terms of ‘Relevant’ - visitors may find plasma relating to thunder in their daily life more meaningful than reading graphical information relating to the plasma. However, the author believes that ISTEs can provide another term ‘Encourage’ – to encourage lifelong learning in order to update the ideas and concepts of science and technology in relation to visitors who come to interact with ISTEs at museums.

In addition, the conceptual understanding of science and technology relating to ISTEs appears in existing classifications of exhibits, such as Sandifer’s (2003) classification which was categorised and combined (1) Technologically novel, (2) Open-ended, (3) User-centred, and (4) Stimulates the senses. However, Boisvert and Slez’s (1995) classification using the three following terms - (1) interaction, (2) concrete/abstract, and (3) information - was a mixture both of the conceptual understanding of interaction design and the conceptual understanding of science and technology. On the contrary, Ghose (2000) uses the four terms - (1) Two-way communication, (2) multiple operation, (3) discovery process, and (4) simulated situation which relates to the conceptual understanding of interaction design rather than conceptual understanding of science and technology.

[6] Social issues
Social issues were found in all four groups of the new ISTEs’ classification. This was particularly true for exhibits that had more space and an area which could support social interaction amongst visitors rather than individual visitors’ interaction. For example, ISTEs arranged around a circular table, ISTEs which had a large circular wall surrounding a group of visitors, and
ISTEs built wider or longer - which could provide an opportunity for many visitors to interact with it at the same time, to solve the problem of limited social interaction as per McFarlane and Latorella’s (2002) recommendation. However, ISTEs should be designed to limit access to a maximum number of visitors per exhibit as Allen and Gutwill’s (2004) comment relating to the need for a small group of visitors’ activities. Also ISTEs should be designed to encourage visitors to support other visitors’ learning as per Watson et al.’s (2002) viewpoint of social relations. Hence, ISTEs in all groups can be developed to support more than one visitor and so unite visitors. Groups 3 and 4 may greatly encourage visitors to become a team and work together as in Hornecker and Buur’s (2006) idea. In addition, people in different cultures might interact with ISTEs in various ways socially. For example, Thai people have learned about queuing from their education in schools and life in the cities. However, a small proportion of Thai people who live in small towns may not be used to queuing and prefer to participate all together at the same time. This queuing behaviour may affect Thai visitors’ participation in ISTEs in groups 3 and 4. ISTEs should be designed for use by many visitors including some of them who are left-handed as Kita and Essegbey’s (2001) comment. Left-handed operation may interfere with other visitors who operate exhibits with their right-hand when they operate ISTEs together.

[7] Emotional values
 Emotional values appear on ISTEs in the new classification of groups 1, 2, 3, and 4 as Desmet et al.’s (2001) suggestions regarding products. Also visitors may present several emotions when they interact with ISTEs - e.g. happiness, surprise, sadness, fear, disgust, and anger (Ekman et al., 1987) and happiness, gratefulness and hopefulness (Padgham and Taylor, 1997). These emotions (such as smiling, crying, and amazement) were revealed by the facial expressions of visitors in a study by Wehrle and Kaiser (2000) and Schaefer (2011) in different cultures.

The emotional values of ISTEs can appear in gesture and movements in all groups of the classification - e.g. visitors lifting up their hands when they win on ISTEs. Most outdoor exhibits in several target museums gave visitors
enjoyment and excitement, similar to Norman (2004) who describes ISTEs’ design, and relates this to peoples’ enjoyment and fear on riding a roller coaster. However, it seems to be that group 3 and group 4 can help young visitors enjoy participating together, as Bainbridge’s (1983) report about human interaction without time pressure. In this case, the children are motivated to spend more time on ISTEs. In contrast, students making a school visit may limit their time on ISTEs. Some ISTEs have few visitors, and the comments of Allen and Gutwill (2004) about boring exhibits may be applicable in those cases. Also the colours of some ISTEs are dark and their dark appearance may discourage visitors from using them. This is in contrast to the use of meaningful colours by Weinschenk (2011). All groups in the new classification of ISTEs have been designed in the digital world by Shibata et al. (1997). Recommendations relating to screen design, animation, and touch screen design are relevant. Several ISTEs stimulating emotion can influence visitors’ behaviour e.g. visitors spending a longer time with ISTEs, with sensations of joy, pleasure, gladness, and social interaction with other visitors. In contrast, visitors may quickly leave ISTEs when they are bored or when they cannot understand how to interact or learn that ISTE.

[8] Age issues

Cultural issues relating to age were found in the classification of groups 1, 2, 3, and 4 where ISTEs may not be able to provide appropriate design features, particularly for visitors such as young children or older people. For example, visitors may be required to provide too much force to operate ISTEs in the case of young children or old people, ISTEs may require visitors to rotate their body or face or bend their body to operate ISTEs, and looking up to control ISTEs with no seat to sit down on. The need for such features might require ergonomic design so as to support these groups of visitors. Most ISTEs in all classes have to provide for operation by children rather than adults or parents, as stated in Schneider and Cheslock’s (2003) report. Hence, some parts of ISTEs made from metal parts such as a long tube (which young children may not be concerned about), nevertheless, can be dangerous e.g. looking through the metal tube without any rubber covers on it. A reminder about taking into account use by children is seen with 3D
glasses for young children from Roussou and Efraimoglou (1999). Also ISTEs should have caution information to remind these groups of visitors of any dangers before they participate with the ISTEs. However, several ISTEs should provide more features than they presently do e.g. a seat to sit on when visitors need to operate ISTEs for a long time, to support senior citizens (as in American culture) described in the report of ASTC (2009) and features of ISTEs to encourage them to be operated and enjoyed by families together.

[9] Disabled people

Disabled visitors may be a minority group of visitors who come with a group of students, families, or a company. However, these groups of people might need special facilities and special support provided by the science museum or centre. There are reports that many science museums in the UK support events for special educational needs (Frontier Economics, 2009) and public engagement for disabled people (Featherstone et al., 2009). However most ISTEs in the target museums did not design optional features to support disabled people, in all groups of the new classification. Adding more space to the area occupied by each exhibit should be provided for disabled people who may be using a wheelchair. Many ISTEs might be uncomfortable and uninviting to people who have lost a leg or hand - similar to the armless Jessica Cox in the USA (Jessica Cox Motivational Services, 2011; Castro, 2009). These groups of disabled people could be taught with the museum’s assistance and the exhibits could be developed to support disabled people in their use of the exhibits.

In addition, the ISTEs should provide more options for blind visitors by providing Braille alphabets, tactile floors, headphones, and audio. More hidden disabilities such as colour blindness might be catered for by museums providing optional features to help these visitors. Colour blind visitors could be helped by increasing the colour contrast in the user interface, or by providing multi-media displays – e.g. the computer science games, internet learning access on computer screens/ touch screens, and science documentaries on the screen. These were found in the target museums, and
should provide a sign language using hand-gestures for deaf persons/hearing-aids as optional features. These features might include two main sign languages if possible - e.g. English sign language and the language in the country of the museum. The author believes that this ‘sign language’ feature could be developed using appropriate open-source software. The software could be shared with other museums where it could be added to the science documentaries or computer science games.

[10] Gender issues

Gender issues were found in several ISTEs in all four groups. These ISTEs involved various factors relating to gender e.g. the operation of an ISTE required too strong a force from women, and women wore inappropriate clothing - e.g. a loose shirt collar, or a short skirt. In some instances the clothing worn by women may cause a piece of material to catch in parts of ISTEs because of its unsuitable design, which could cause an accident. However, it is quite difficult to predict which gender may have a better interaction with an ISTE in different cultures.

Brislin’s (1993) viewpoint that males prefer a competitive element rather than females would suggest males prefer this type of interaction. Most ISTEs in the target museums provided features that favoured males showing their power of force rather than females who preferred ISTEs supporting their emotional values. Also ISTEs should be developed to feature interactions along the lines of Inkpen et al.’s (1994) perspective of supporting a large group of girls together, if desired. Further, manual skills of males and females involved with several ISTEs may differ as Pedersen et al.’s (2003) report of the different interaction of boys and girls where hand skills were required in the use of the ISTE. Extensive experiment is needed to find out if manual skill levels in every exhibit vary with gender. If ISTEs do not need to take account of differences in manual skills between men and women, there will be much less of a difference between men and women in the learning and use of ISTEs.

5.6.3 Phase 3: Overview of the online questionnaire
The online questionnaire will be discussed in three main areas in the overview as follows.

[1] The views of the museum experts
A majority of responses of the experts came from Europe and North America where the large geographical regions with many science museums and centres are located. The distinguishing features of these two groups were that many experts in Europe believed conceptual understanding was slightly more important than language issues. The experts in North America strongly felt that language issues were more important than conceptual understanding. The analysis shown in Figure 5.76 (influence of culture) and Figure 5.77 (difference between various cultures) has tried to highlight the different viewpoints between experts in different regions of the world.

[2] Transferring cross cultures into inclusive designs
Several experts believed that cultural issues influenced the development of their exhibits into inclusive designs. For example with physical skills, an expert replied that “We have an exhibit called ‘coded music’ where a famous nursery rhyme is bar-coded on to a freely rotatable drum, which when turned clockwise reproduces the tune. Some people turn it in reverse manner but they soon learn the right way too” (Museum Director, India).

On the contrary, some experts disagreed that cultural issues were important and influenced visitor interaction. For instance with physical skills, there was a comment that “There are no cultural barriers. If community is habitual to a particular method, children try to follow the same. If they feel inconvenient in doing so they try the other way” (Dr. Shaik Jeelani Saheb, the Curator of Science City, Kolkata in India).

[3] The expectations of the results from many experts
Many experts requested the results of the online survey. They commented that they would like to receive the report of this study in order to help to improve or develop their interactive science exhibits to take account of cross cultures and to support local visitors and international visitors in the future.
Moreover, many experts provided positive comments and encouraged support for the online survey, for example:

- “I found your topic of research most interesting and there is much to discuss… Good luck with your project” (Mr. Stephen Pizzey, Director, the Observatory Science Centre, UK).
- “Sure – I’ll do the survey tomorrow” (Sean Duran, Vice President of Exhibitions and Programs, the Miami Science Museum, USA).
- “I look forward to hearing the results of your study; it may assist us our future design and planning of exhibits.” (Mr. Alan Brien, Chief executive officer, the Scitech, Australia).
- “My pleasure and good luck with your work. Would like to see the results when you have completed” (Professor Patricia Vickers-Rich, Director, the Monash Science Centre, Australia).
- “I have completed your survey. Good luck on completing your research.” (Ms. Karen Marie Giacobassi, educator, the Museo Galileo, Italy).
- “I will put some things together for you to read. It was good hearing from you and I wish you the best in your studies.” (Museum educator, USA).

### 5.7 Critique of online survey method

Several limitations of the study and feasible improvements were found through the course of the study. The major issues in this case study were as follows.

#### 5.7.1 Unequal numbers of the sample sizes of the experts

In Table 5.9 (Number of respondents in each culture), this study indicated that the sample sizes of the experts for each country could not be controlled so as to be equal in size. Some countries such as the UK and the USA have many science museums and can offer a large number of experts to complete the online survey. This is compared with other countries - such as Singapore and Brunei - which have only a few science museums and so only a small number of experts who could complete the online survey. Some museums
were only able to offer one expert to respond to the online survey - such as the director or science educator. Other museums provided 1-2 experts and more than one position such as the National Museum of Natural Science in Taiwan offering a curator, a researcher, and a volunteer to respond to the online survey. This significant support from these museums was very helpful in providing more information from various groups of experts.

5.7.2 Limitations of the ‘designers’ group
The exhibit designers, who are a major group relating to the interaction design of ISTEts, comprised only three people. Some other experts were involved in design of exhibits, but all of them classified themselves differently, such as exhibition manager, exhibit developer and exhibitor of projects. Most of the museums offered two groups for the main response, such as the directors and science educators. It is possible that these two groups are important in the organisation of science education through ISTEts. However, most ISTEts should be concerned with developing their exhibits taking into account various cultures in science education and interaction design.

5.8 Summary
The 10 dimensions of the cultural issues found in this research were

- Physical skills
- Technologies issues
- Language issues
- Visual cultures
- Conceptual understanding
- Social issues
- Emotional values
- Age issues
- Disable people
- Gender issues

All these dimensions of cultural issues were regarded as relevant to museum exhibit design, but the most important issue established by the survey in this study was the language issue, followed by conceptual understanding. The
findings of the study should be disseminated to the experts in science museums and science centres in the world, and many experts have already asked for the results. As a result of this research, the 10 cultural issues which have to be taken into account in inclusive design have been specified so that they can be used to develop ISTE in the future.

Despite some limitations, the online survey did meet the overall aims of this study. It was completed by 66 male and 55 female experts who had various positions at the science museums and other related institutions worldwide. It included directors, educators, designers and staff in other positions. They were involved because they had relevant experience, having been involved with ISTE and their use by local and international visitors.

Most experts in the museums in the world who completed the online survey believed that the 10 dimensions of the cultural issues were apparent in the use of ISTE by visitors. The results of the online survey show that there are differences between people of different cultures and that these have a significant effect on visitors’ interaction through the use of ISTE.

The 10 cultural issues could affect the experience and understanding of international visitors to the science museums. These cultural issues might also affect local visitors to science museums in their own countries, because of the different interactions and understanding of minority groups of people living in the same country. The national people’s characteristics might have diverse dialects, languages, conceptual ideas of science, physical skills and technological devices. If the interactive exhibit designers were able to take account of cultural issues, it could positively affect the experience of visitors who were a minority group in any country, and help them to learn from the exhibits.
Chapter 6
Case study 3:
Language issues and conceptual understanding

6.1 Introduction

This chapter builds on the findings from the previous study described in Chapter 5. Based on the results of the online survey, the most important cultural issues were found to be respectively: language issues and conceptual understanding. In the study reported in this chapter, a paper-based questionnaire was used to determine visitors’ opinions of three interactive science and technology exhibits (ISTEs) at the National Space Centre, Leicester in the UK. The outcome of the visitor experience in terms of visitors’ understanding and learning of science was evaluated using the survey results.

<table>
<thead>
<tr>
<th>Research questions of the enquiry:</th>
</tr>
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<tbody>
<tr>
<td>RQ 1 What is culture, and what is the meaning of cultural differences?</td>
</tr>
<tr>
<td>RQ 2 What is meant by interaction, and what is an interactive science and technology exhibit?</td>
</tr>
<tr>
<td>RQ 3 Why is the classification of interactive science and technology exhibits so important for today and the future; and what classifications are there?</td>
</tr>
<tr>
<td>RQ 4 How to define the relation between the cultural differences and interactive science and technology exhibits, and what categories of cultural differences are there?</td>
</tr>
<tr>
<td>RQ 5 What interest have the experts of the museums of science in culture influencing the use of interactive science and technology exhibits; and which cultural issues do they believe are the most important?</td>
</tr>
<tr>
<td><strong>RQ 6</strong> How do the characteristics of the interactive science and technology exhibit take account of cultural differences which affect learning?</td>
</tr>
<tr>
<td>RQ 7 What are other factors which significantly contribute to cultural differences in learning to use and using interactive science and technology exhibits? For example, age, gender, and educational levels. Why are these factors related?</td>
</tr>
<tr>
<td>RQ 8 How can interactive science and technology exhibits be developed to capitalise more successfully on cultural differences?</td>
</tr>
</tbody>
</table>

Table 6.1: Research questions in chapter 6
6.2 Background

The results of case study 2 (previous chapter) led to the conclusion that the most important cultural issues related to language and conceptual understanding. The responses to the online survey provided by 121 experts from 109 science museums in 37 countries around the world had similar numerical values for these two issues (27.27%; 21.49%). Hence, these two cultural outcomes became leading candidates for the investigation of understanding and learning of science and experiences of visitors using ISTEs in science museums.

6.3 Aims and objectives

The overall aim of this study was to examine the two important cultural issues which were: language issues and conceptual understanding. In particular how these two cultural issues may significantly influence local and international visitors’ experiences when using the ISTEs.

The particular study objectives were to investigate:

► the cultural issues such as language issues and conceptual understanding and how these may influence visitors’ understanding and learning of science when using ISTEs.

► the learning that may take place between pre and post use of an ISTE, relating to language issues in terms of scientific words.

► the level of conceptual understanding of the visitors as indicated by their self-assessments and also compared with scoring by the author.

► the learning outcome as shown by better understanding, analysed according to educational levels and ethnic groups.

► the visitors’ experience which might be captured by their surveys after they interacted with the three ISTEs.
6.4 Study rationale

6.4.1 Choice of methods
This case study will use methods which are a mixture of qualitative and the quantitative research. First, the quantitative data was analysed using the two statistical tests - ‘Wilcoxon test’ and ‘Mann-Whitney U test’ - to analyse the results of paper-based questionnaires. Second, the qualitative data relating to the experience, learning and understanding outcomes were elicited from the respondents’ written responses on the paper-based questionnaires. Further, video recording of observations of visitors were made to be used to examine the relationships between experience and learning, and understanding outcomes through the interactions based on the cultural issues identified by the qualitative research.

The Wilcoxon test is used to measure whether there is statistically significant difference in the understanding of scientific words by individuals with the same ethnic grouping, comparing the pre- and post-test phases of the questionnaire (i.e. within subjects test). It is used to study language issues in relation to scientific words, based on potential impact of using the exhibit. The Mann-Whitney test is used to measure whether there is statistically significant difference in the understanding of scientific words, comparing the results of different ethnic groups at both pre and post test phases (i.e. between subjects test). It is used to study language issues in relation to scientific words, based on potential differences between ethnic groups.

6.4.2 Experience outcomes
Roschelle (1995) indicated that all learners have prior knowledge which each person has acquired in subjects in which they have an interest. That learning can take place in a variety of ways. First, learners might add their new experiences to their previous knowledge of theory and practise. Second, the learners could accept some of the previous experience and merge it with their new thinking. Third, the learners thoroughly transfer all the new experience into their underlying assumptions relating to their speech, visualisation, and perception.
In addition, Anderson and Lucas (1997) remarked that the experience at the science museums was important and fundamental to the learning process. The research objectives of the museums might be to achieve entertainment or education or both.

6.4.3 Learning outcomes

Northern Ireland Curriculum (2007, p.9) stated that “We are all familiar with learning being described in terms of what pupils know, understand and are able to do”.

To investigate the learning objectives and learning outcomes, Owen-Jackson (2007, p.107) recommended identifying:

- “what pupils will learn – the learning objective;
- What they will do – pupils activity in the lesson;
- What they will produce to demonstrate learning – the learning outcome”.

However, Owen-Jackson (2007)’s framework for lesson-planning could also be applied to measure the learning outcomes at the science museums. Hence, using these two approaches - the learning objectives and learning outcomes - could be considered by examining:

- what the visitors will learn as their learning objective.
- what they could do in their interactions with the ISTEIs and other people during their visit.
- what they could create to demonstrate their learning outcomes.

In addition, Davidsson and Jakobsson (2012) claimed that artefacts at science and technology centres and museums may increasingly offer learning involving interactions with other visitors and the exhibits, and other visitors and museum staff. For example, other visitors and staff may have discussions or talk about an exhibit and these interactions may provide further opportunities for visitors’ learning from and with other staff and visitors.
6.4.4 Understanding outcomes
Macdonald (2006, p. 366) claimed that “In 1928, Robinson developed the concepts of ‘attracting power,’ the power of an exhibit to attract viewers, measured by what proportion of visitors stopped to look, and ‘holding power,’ the length of time spent looking.” Nevertheless, Robinson et al. (1928) observed visitors interacting with exhibits - e.g. pictures and paintings - in galleries of the four museums, but these researchers did not describe including interactive science exhibits in their research. Additionally, Rhee and Kim (2013) used these two terms of ‘power’ when referring to interactive exhibits in their research and they reported that exhibits with a ‘high holding power’ may follow a ‘low attracting power’. This high rate of ‘holding power’ could happen in a narrow walking area alongside the exhibits which would crowd visitors. Further, the concepts and terms ‘attracting power’ and ‘holding power’ were continually used during 1980s in the UK. On the other hand, many researchers in the USA preferred to approach the visitors’ assessments using ‘pre and post-testing of visitors’ (Macdonald, 2006).

According to research on the ‘Science Vocabulary Load of Selected Secondary Science Textbooks’ written by Groves (1995), he pointed out that students might find it difficult to memorise many scientific words. Therefore students should be led to understand the meaning of scientific concepts which in turn could lead students to improve their correct understanding of scientific vocabulary. The research of Groves (1995) showed a significant relationship between conceptual understanding of scientific knowledge and language issues within scientific vocabulary in school science education.

6.5 Methods
6.5.1 The target groups
The respondents are the local and international visitors of the museum who became the main target groups in this case study. In this case study, ethnic groups were used to investigate the cultural features of the respondents. These may relate to the two cultural issues - language issues and conceptual understanding. Fearon (2003) pointed out that ethnic groups regularly had members who shared cultural characteristics together. For instance,
customs, official language and religion were examples of characteristics of a large number of members in the group. Simpson and Akinwale (2007) claimed that social conditions and particular populations were classified using ethnic groups. An example of the use of such ethnic group data might be in the assessment of international migration policy.

Principally, National Statistics (2013) recommended the use of five main ethnic groups in a survey in England. These were:
1. White
2. Mixed or Multiple ethnic groups
3. Asian/ Asian British
4. Black/ African / Caribbean/ Black British
5. Other ethnic group

Another classification of the ethnic groups in the UK, National Archives (2013) suggested five major ethnic groups and its codes as a National Standard were:
A: White
B: Mixed
C: Asian or Asian British
D: Black or Black British
E: Chinese or other ethnic group

The paper-based survey in this case study has chosen to use the five major ethnic groups as used by National Archives (2013) because it states the Chinese nationality.

6.5.2 Searching for the science museum

The science museum for this research should be conveniently situated to allow the opportunity of several day visits within the time constraints of the research. Hence, the museums near Loughborough town were examined and only two science museums were found in this area - the Snibston Discovery Museum in Coalville Town and the National Space Centre (NSC) in Leicester City. A letter describing the research study was emailed with
contact information to these museums. The NSC in the UK offered to participate in this research.

6.5.3 Finding the research gallery at the National Space Centre (NSC)

All of the galleries in the NSC were visited and observations were made at each of them. One of these galleries would become the research gallery and this was selected by using four criteria as follows:

- **Controlled Walkway**: the floor plan of any gallery should control the visitors’ movements along the walkways. This control should ensure the visitors directly return a paper-based questionnaire at the desk in the main entrance of the gallery. If any gallery at the museum had different points of entry and exit that would rule it out because it could allow visitors to walk past on to other galleries without returning their questionnaires.

- **Many interactive science and technology exhibits (ISTEs)**: the research gallery must have ISTE s rather than having artificial models and graphic panels of space, planets, space craft, and stars.

- **Not too far from each other**: the research gallery needs to have many ISTE s but the exhibits need to be located close to each other. Thus the visitors would find moving through the selected exhibits could be done conveniently in the same gallery.

- **No staff**: no volunteers or staff should constantly stay in the research gallery to provide scientific information relevant to the exhibits to local and international visitors. It is acceptable that the staff may walk in sometimes to inspect exhibits in the gallery.
The following table gives an overview of the galleries’ description and the information relating to the eight exhibition rooms taken from the website of the NSC (National Space Centre, 2012). The symbol ‘✓’ (tick) in the table marks the selection of this exhibit, and the symbol ‘✗’ (cross) shows where the exhibit did not provide the characteristics mentioned in the criterion, so was not selected.

<table>
<thead>
<tr>
<th>Exhibit gallery</th>
<th>Controlled Walkway</th>
<th>Many interactive exhibits</th>
<th>Not too far from each other</th>
<th>No staff</th>
<th>Information</th>
<th>Selected gallery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sir Patrick Moore Planetarium</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>It is a full 360º dome cinema with no extra cost.</td>
<td>×</td>
</tr>
<tr>
<td>The Rocket Tower</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>It has the 42 metre high iconic ‘Rocket Tower’ with a small interactive boost of the Thor Able launch rocket system.</td>
<td>×</td>
</tr>
<tr>
<td>Into Space</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td>Tours of the gallery are given about astronauts, spacesuits and journey into space.</td>
<td>×</td>
</tr>
<tr>
<td>Exploring the Universe</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>It has many interactive exhibits for discovering the wonders of the universe such as the ‘Big Bang’, ‘Alien head’, and ‘A trip through a wormhole’.</td>
<td>✓</td>
</tr>
<tr>
<td>The Planets</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>The Planets gallery displays the planets - Mercury, Venus, Mars, Jupiter, Saturn, Uranus and Neptune.</td>
<td>×</td>
</tr>
<tr>
<td>Orbiting Earth</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>The highlighted themes in this gallery are: weather forecasting, watching the impact of an asteroid close to the Earth, and Satellite navigation.</td>
<td>×</td>
</tr>
<tr>
<td>Exhibit gallery</td>
<td>Controlled Walkway</td>
<td>Many interactive exhibits</td>
<td>Not too far from each other</td>
<td>No staff</td>
<td>Information</td>
<td>Selected gallery</td>
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<td>------------------</td>
</tr>
<tr>
<td>Space now</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>It shows what is ‘Happening in space right now’ such as the ExoMars rover robot on the Mars Yard, including sitting on the seat to watch the presentations of scientific questions such as ‘What is dark matter?’ and ‘Are we alone in the Universe?’</td>
<td>✗</td>
</tr>
<tr>
<td>Tranquillity base</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>There are many missions in this gallery such as the SIM as a 3D simulated ride, the mine on the moon rock, Life Support on a moon night and making a postcard on the moon walk.</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.2: The decision making for choosing the research gallery

The gallery of ‘Exploring the Universe’ clearly meets the four criteria required for the research gallery in the case study.

### 6.5.4 Identifying the three samplings of ISTEs

‘Exploring the Universe’ gallery involves numerous ISTEs demonstrating particular scientific knowledge of the universe, space and physics. The three ISTEs - ‘Gravity Well’, ‘Big Bang’ and ‘Getting the picture’ exhibits illustrated in the three following figures were approved for use in the sampling and were used to develop the questions for the paper-based questionnaire.
Figure 6.1: ‘Gravity Well’ exhibit

Figure 6.2: ‘Big Bang’ exhibit
Figure 6.3: ‘Getting the picture’ exhibit

The ‘Gravity Well’ exhibit, the ‘Big Bang’ exhibit and the ‘Getting the picture’ exhibit were categorised into the different groups of the interactive science exhibit classification in the following table.

<table>
<thead>
<tr>
<th>Interactive science exhibits</th>
<th>Characteristics</th>
<th>The groups in the classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gravity Well</td>
<td>• One or more visitor could interact with it.</td>
<td>Group 2: Simple interaction with complex understanding</td>
</tr>
<tr>
<td></td>
<td>• Interaction with the exhibit required</td>
<td></td>
</tr>
</tbody>
</table>

252
Gravity Well (continued)

- The concept of the ‘Gravity Well’ exhibit was to transfer scientific knowledge by giving more complex information to the visitors. For example, the visitors needed to examine the movement of a spinning ball around a well until it dropped in a hole at the centre of the well. Visitors might not understand why the ball dropped into the hollow through the force of gravity.

- The visitors might not fully understand the message that the ‘Gravity Well’ exhibit was communicating. For example, the ‘Gravity Well’ exhibit presented a model of gravity. Hence the understanding required could be considered to be complex.

2. Big Bang

- It could be used by more than one visitor such as two to four visitors. In addition, Big Bang exhibit could not be manipulated by only one visitor. For example, two visitors could rotate two discs quickly on their sides and another two visitors can help them to push the two buttons.

- The Big Bang exhibit requires various styles of physical interaction. For instance, the visitor’s hands manipulating the exhibits in different ways such as using one hand to rotate a disc and another hand to

Group 3: Multiple interactions with direct understanding
Interactions with the ‘Big Bang’ exhibit required more senses to explore the scientific concept which the visitors interacted with when it worked. For example, two visitors rotate the two discs very quickly until the two particles move and turn around on their opposite sides. Then the two visitors press a button which scatters their particles and they hit together. If the two visitors did not manipulate the discs at adequate speeds, the two particles would not have a high enough speed to crash into each other. The visitors will understand the concept of the Big Bang which arose from the impact of particles caused by their launching interactions.

The concept behind the Big Bang exhibit was to transfer scientific knowledge to the visitors thoughtfully and by direct understanding. For example, the visitors could comprehend that Big Bang exhibit is a model of impacting particles called the Big Bang.

3. Getting the picture

- Locating the picture exhibit where it could be used by more than one visitor, because it has two focal points on the top and bottom of the parabolic discs.

- Interactions with ‘Getting the picture’ exhibit required the various patterns of physical skills on the same
objects. For example, the visitors could use one or two hands for the interactions. Firstly touching the two parabolic discs, then moving their hands up and down; waving their hands until they could feel the warm areas on the two focal points of the two discs.

- Interaction with the ‘Getting the picture’ exhibit required more senses to investigate the scientific concept of focus through their interaction with how it worked. For example, the visitors need to use their hands to touch, and the skin of their hand for feeling and finding the warm areas of the two focal points. The visitors may use their palms’ skin or the back of their hands’ skin, including using their arm’s skin for experimenting by themselves.

- ‘Getting the picture’ exhibit transfers the scientific concept to the visitors as complex understanding. For instance, the two focal points of heat offer the visitors to feel directly on their palms; hands including their arms which the visitors could understand about the focal point. But the name of the exhibit ‘Getting the picture’ might not relate well to the feeling of the heat and could confuse the visitors as to the meaning of the picture.

<table>
<thead>
<tr>
<th>Table 6.3: The characteristics of the three interactive science exhibits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Getting the picture</strong> (continued)</td>
</tr>
</tbody>
</table>
The interactive science exhibit in group 1 (Simple interaction with direct understanding, described in Chapter 4) is easy to use and understand; the visitors did not need to have too much background scientific knowledge. For instance, an exhibit with the six alien cartoons’ pictures in the ‘Exploring the Universe’ gallery illustrated in the following figure could be classified as in group 1. It has three parts of the hexagonal prism which the visitors could rotate until all six images of the aliens’ bodies on a hexagonal prism are in the correct positions. This exhibit may suit young visitors and it might develop children’s observation by them trying to match all of these aliens’ pictures. Although this group 1 exhibit did not provide any information as a guideline for the ways visitors should interact with the exhibit, the visitors could understand this exhibit and use it smoothly by simple interaction such as touching, rotating and noticing.

![Figure 6.4: An example of the exhibit in group 1](image)

However, no exhibits in group 1 were included in the questionnaire, because it would take too much time for the visitors to complete the questionnaire for four exhibits. Therefore, only exhibits from groups 2, 3, and 4 of the new classification were represented in the questionnaire.

A floor plan of the ‘Exploring the Universe’ gallery is shown in the following figure. There are three major science exhibits and a desk for the questionnaires separated by the barriers provided by many graphic panels and other exhibits. When any group of visitors agrees to become respondents for answering the questionnaire, an explanation for filling in the
questionnaire and finding the locations of the three exhibits was then provided to them.

Figure 6.5: A floor plan of Exploring the Universe gallery

6.5.5 Creating a paper-based questionnaire
An average number of the visitors arriving at the National Space Centre were reported to be about 300 people per day. This number was the estimate provided by management at the National Space Centre. Therefore, 300 photocopies of the questionnaire were assigned to the respondents who are local and international visitors entering the museum, until these copies were all used up. The period of the paper-based survey was between 13 March 2013 and 26 March 2013.

The Foundation for Critical Thinking (2014, para 10) defined “Critical thinking is that mode of thinking - about any subject, content, or problem - in which the thinker improves the quality of his or her thinking by skillfully taking charge of the structures inherent in thinking and imposing intellectual standards upon them.” Also critical thinking is the idea for using a reason for a judgement or the process which is estimated or assessed in the ability of rationally, coherent, well-argued way, and reflective thinking (Lau, 2012; Moon, 2005; Thomson, 2009). For instance, Ennis and Weir (1985) developed the open-endedness test which broadly scores the logical dimension of critical thinking. This test provides the situation of an argument in a realistic context - e.g. a newspaper, a letter to the editor - which
responders should write their statements to make sense, not jargon, and express more clearly. In addition, critical thinking was defined as an important thoughtful activity to develop students’ learning by applying evidence or an argument in order to solve a problem and to achieve rational conclusions (Australian Curriculum, 2013).

In this case study, a paper-based questionnaire was designed to use opened-end questions with local and international visitors, based on the critical thinking approach above. The scientific words used to assess language issues (described in the literature review) were found from the information panels of the three interactive science exhibits. These were ‘gravity’, ‘particle’ and ‘focus’. The word ‘gravity’ is part of the word ‘Gravity Well’ in one position on the exhibit and it is also displayed on an information panel on a circular bar exhibit, see Figure 6.6. The second word ‘particle’ is posted on both panels of the two-side corners of the ‘Big Bang’ exhibit, see Figure 6.7. The last word ‘focus’ appears in four positions on a graphic board of ‘Getting the picture’ exhibit, see Figure 6.8. Further, these positions represent the different properties in English grammar - such as noun in the first position, passive verb in the second and third position, and an active verb in the fourth position.
Figure 6.6: An information panel of Gravity Well exhibit

Figure 6.7: An information panel of the Big Bang exhibit
Figure 6.8: An information panel of Getting the picture exhibit

The main reason for using the phrase ‘Big Bang’ exhibit on the questionnaire rather than the ‘collider’ exhibit was because the word ‘Big Bang’ was exhibited on the side of the exhibit whereas the word ‘collider’ is only displayed on a small panel on its table. Hence, the visitors first see the phrase ‘Big Bang’ but then they may probably only see the word ‘collider’ while they go to read the small panel.
A paper-based questionnaire was developed in two stages as follows.

- An initial version was used in a pilot survey which was approved by an educator staff group at the National Space Centre. Following this version, the questionnaire was then improved by adding information such as adding the name of exhibits, editing the phrase ‘official language’ to ‘first language’ and changing the pictures of the three interactive science exhibits.

- For the revised second version, used for data collection in this study, the first section collected the personal information relating to each visitor such as gender, age range (under 20, 20-29, 30-39, 40-49, 50-59, 60+), study level (primary school, secondary school, college, undergraduate, postgraduate, higher), employment, ethnic group, nationality, the country where they live and were born in, and their first language. The second section of the questionnaire was used as a pre-test to explore the visitor experiences with the three exhibits and to discover their understanding of the meaning of the scientific words gravity, particle, and focus. The third section was used as a post-test evaluation of learning, and enquired about the learning and understanding outcome of the visitor who had used the same three exhibits including the meaning of the previous scientific words. The third section required the visitors to assess their understanding of three ISTEs by themselves using five levels of understanding on a Likert scale (scale points: not at all, very little, moderate, a lot, and very well. This is shown in Appendix 13.
6.5.6 Developing a criteria for the questionnaire evaluation

The language issues and conceptual understanding were to be examined by using the questionnaire. The language issues would be investigated by the respondents’ explanations of the three scientific words. The conceptual understanding would be investigated by the respondents’ open ended descriptions of how the three interactive exhibits work.

In this case study, certain basic rules were set and followed in the survey submissions and the surveys were given a score, described below. Grammar and spelling mistakes for each respondent were ignored as follows:

- Misspelling of any word, no full stop at the end of sentence and grammatical errors.
- Both written in upper and lower case English characters mixed together in any sentence such as ‘the GraviTY is the FoRce’.

Before the language issues in the pre-test and post-test were examined; the definitions of the three main scientific words were researched from the perspective of several authors. The score given to the person was based on looking at all of the definitions.

<table>
<thead>
<tr>
<th>The scientific words</th>
<th>definitions</th>
<th>authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity</td>
<td>“Gravity acts upon mass and gives objects weight ... Gravity pulls all objects (including gases) towards the centre of the earth.”</td>
<td>Woodhouse Primary School (2013, p.1)</td>
</tr>
<tr>
<td></td>
<td>“The force of gravity is the force with which the earth, moon, or other massively large object attracts another object towards itself. By definition, this is the weight of the object.”</td>
<td>The Physics Classroom (2013, para.2)</td>
</tr>
<tr>
<td>Gravity (continued)</td>
<td>&quot;The gravitational field strength of the Earth is 10 N/kg and its acceleration of free-fall is 10 m/s(^2).&quot;</td>
<td>BBC (2013, para.1)</td>
</tr>
<tr>
<td></td>
<td>&quot;Gravity is a force pulling together all matter (which is anything you can physically touch). The more matter, the more gravity, so things that have a lot of matter such as planets and moons and stars pull more strongly&quot;.</td>
<td>Qualitative Reasoning Group (2013, para.1)</td>
</tr>
<tr>
<td></td>
<td>&quot;Gravity is what makes the planets orbit the stars--like Earth orbits our star, the Sun. Gravity is what makes the stars clump together in huge, swirling galaxies&quot;.</td>
<td>Nasa (2011, para.1)</td>
</tr>
</tbody>
</table>

The word ‘particle’ means “A tiny mass of material”. It has originated from the Latin ‘particula’.

"The particles might be atoms, molecules or ions. Use of the general term ‘particle’ means the precise nature of the particles does not have to be specified".

"Everything in the universe, from stars and planets, to you and the chair that you’re sitting on, is made from the same basic building blocks - particles of matter".

"Particle physics is a search for the most primitive, primordial, unchanging and indestructible forms of matter and the rules by which they combine to compose all the things of the physical world. It deals with matter, energy, space, and time".

| Particle | Biology Online (2013, para.1) |
| | "Particle physics is a search for the most primitive, primordial, unchanging and indestructible forms of matter and the rules by which they combine to compose all the things of the physical world. It deals with matter, energy, space, and time". | Lederman (2013, para.4) |

| Qualitative Reasoning Group (2013, para.1) | "Gravity is what makes the planets orbit the stars--like Earth orbits our star, the Sun. Gravity is what makes the stars clump together in huge, swirling galaxies". |

| Nasa (2011, para.1) | "Gravity is what makes the planets orbit the stars--like Earth orbits our star, the Sun. Gravity is what makes the stars clump together in huge, swirling galaxies". |

| Biology Online (2013, para.1) | "The word ‘particle’ means “A tiny mass of material”. It has originated from the Latin ‘particula’." |
| | "Particle physics is a search for the most primitive, primordial, unchanging and indestructible forms of matter and the rules by which they combine to compose all the things of the physical world. It deals with matter, energy, space, and time". | Lederman (2013, para.4) |
"The goal of particle physics is to understand the fundamental constituents of matter and their mutual interactions. ... The ‘standard model’ of particle physics is that the fundamental constituents are quarks, leptons, gauge bosons and the graviton, interacting via the strong, electroweak and gravitational interactions".

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**Table 6.4: The three scientific words with their definitions**

<table>
<thead>
<tr>
<th>Particle (continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;...the position of a viewed object or the adjustment of an optical device necessary to produce a clear image&quot;.</td>
</tr>
<tr>
<td>&quot;A point in which the rays of light meet, after being reflected or refracted, and at which the image is formed; as, the focus of a lens or mirror&quot;.</td>
</tr>
<tr>
<td>&quot;a point at which waves of light, sound, etc. meet after reflection or refraction; the point from which waves of light, sound, etc. seem to come&quot;.</td>
</tr>
<tr>
<td>&quot;a point of convergence of light or other electromagnetic radiation, particles, sound waves, etc, or a point from which they appear to diverge&quot;.</td>
</tr>
</tbody>
</table>

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Brower et al. (2013, para.1)
Definitions (2013, para.3)
Thinkexist (2013, para.3)
eLook (2013, para.6)
Oxford Advanced Learner’s Dictionary (2013b, para.2)
Collins (2013, p.284)
Furthermore, in one of the definitions of gravity, BBC (2013) advised that the gravitational field creates an acceleration of $10 \text{ m/s}^2$ but Physics Classroom (2013) pointed out that the most accurate value for the acceleration of gravity is about $9.8 \text{ m/s}^2$.

The Rubric scale - ‘Holistic Rubrics’ (explained in the Methodology chapter) - was used to develop criteria for generating a score in both cases – that of the three scientific words and the conceptual understandings of the three interactive science and technology exhibits (ISTEs) between 0-5 levels of understanding. In addition, the self-assessment scores of the respondents were converted from the Likert scale into levels of understanding by comparing the numbers of each score level as in the following table. Then, all converted self-assessment scores were correlated with the ranking score by the researcher’s assessment.

<table>
<thead>
<tr>
<th>The level of understanding</th>
<th>Criteria</th>
<th>Score levels</th>
</tr>
</thead>
</table>
| Very well                 | • The respondent could fluently explain the scientific words/exhibits and correct description.  
                           | • The respondent might show some scientific words which came from his/ her previous knowledge to support the answer.  
                           | • His/ her answer may be more advanced than the information provided by the exhibit. | 5             |
| A lot                     | • The respondent could explain the scientific words/exhibits well.  
                           | • The respondent used some scientific words which came from his/ her previous knowledge to support the answer.  
                           | • A few inaccuracies about the scientific words or exhibits appear in the answer. | 4             |
| Moderate                  | • The respondent could generally explain the scientific words/exhibits in common contents.  
                           | • The respondent might show some scientific words which came from his/ her previous knowledge to support the answer.  
                           | • Some misconceptions of the scientific concept appear in the answer. | 3             |
### Table 6.5: Criteria for giving a score for the questionnaire

In addition, the three main conditions (as below) of the score levels needed to be set up for comparing the score between the pre and post assessments of the three scientific words, before each score level were given, as follows.

<table>
<thead>
<tr>
<th>The level of understanding</th>
<th>Criteria</th>
<th>Score levels</th>
</tr>
</thead>
</table>
| Very little               | • The respondent could supply only a little information and a partial explanation in their answer.  
                          | • The respondent provided very little explanation of the scientific words or exhibits.  
                          | • Many misconceptions appeared in the answer. | 2 |
| Not at all                | • Many misconceptions appeared in the answer.  
                          | • The respondent tried to providing an explanation relating to the scientific words/exhibits, but his/her explanation was different in various ways from the scientific words or exhibits' definition. | 1 |
| N/A                       | For the pre-test, N/A was defined such as  
                          | • No answer or blank - no information.  
                          | • The respondent gave some information such as ‘I don’t know’ and ‘not sure’.
                          | • The respondent wrote only the symbols such as ‘?’, ‘*’ and ‘!’.  
                          | • The respondent gave an alternative explanation which did not relate to the scientific words/exhibits. | 0 |
|                           | For the post-test, the level N/A was different from the pre-test as follows:  
                          | • If the answer in the post-test was, for example, N/A or blank – no information, ‘I don’t know’, or ‘not sure’, or just symbols were provided as an answer, the same score (0-5) was given as for the pre-test or adjusted because of what they say. | 0 - 5 |
• **The first condition:** If the answer in the post-test had more correct content than in the answer in the pre-test, the score will be given at a higher level than the answer in the pre-test. It means that the respondent could clearly understand the scientific words/ exhibits and had a better idea after he/ she interacted with the exhibits.

• **The second condition:** If the answer in the post-test did not change content too much or the answer demonstrated more incorrect context than in the answers of the pre-test, the score will be given at the same level as the answer in the pre-test. In this case, the respondent did not get any new information or knowledge from the exhibit which he/ she manipulated.

• **The third condition:** If the answer of the post-test notably demonstrated much more incorrect information or ignorance in the answer than in the answer of the pre-test, the score will be given at the lower level than the answer in the pre-test. In this case, the respondent could not understand clearly the scientific words/ exhibits after he/ she operated the exhibits.

### 6.5.7 Video recording and observations

Various types of museum visitors such as an individual, partners and family or school groups who become respondents of the paper-based questionnaire were invited to give their permission for video recording their interactions. Initially, the respondents were provided with an information sheet describing the research project and after reading and understanding this they should accept the terms of the participation and sign an informed consent form giving their agreement. A sample of the respondents, who allowed their video interactions with the three interactive science exhibits to be recorded, were observed for their behaviour relevant to the dimensions of the cultural issues. All video clips of the interactions were examined.
6.6 Results

The results in case study 3 – overall results, users’ experience of exhibits, the two main cultural issues, and the results of video recording and observations – are described as follows.

6.6.1 Overall results

239 completed paper based questionnaires were placed back on the information desk in the ‘Exploring the Universe’ gallery over a period of 10 days. Some visitors could not return the questionnaire and they provided several reasons for not bringing the questionnaire with them when they were leaving. For example, the school groups had a limited amount of time for their visit to the museum. The students promised to hand the questionnaire back after they went to other galleries.

Although the aims and objectives of the survey were thoroughly explained to the visitors and they were provided with the information for ethical clearance, 27 respondents could not finish the post-test of the survey, for several reasons. For instance, the teachers needed to take their student groups to other galleries. Some of the older visitors did not complete the second section of the survey replying that they preferred to enjoy themselves as general tourists in the museum. The results of the numbers of respondents on each day of the study are shown in the following table.

<table>
<thead>
<tr>
<th>Date</th>
<th>A number of Respondents</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td></td>
</tr>
<tr>
<td>13/03/2013</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>14/03/2013</td>
<td>8</td>
<td>19</td>
<td>27</td>
</tr>
<tr>
<td>15/03/2013</td>
<td>4</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>16/03/2013</td>
<td>19</td>
<td>24</td>
<td>43</td>
</tr>
<tr>
<td>17/03/2013</td>
<td>17</td>
<td>15</td>
<td>32</td>
</tr>
<tr>
<td>20/03/2013</td>
<td>7</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>23/03/2013</td>
<td>24</td>
<td>18</td>
<td>42</td>
</tr>
<tr>
<td>24/03/2013</td>
<td>18</td>
<td>16</td>
<td>34</td>
</tr>
<tr>
<td>25/03/2013</td>
<td>8</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>26/03/2013</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>114</td>
<td>125</td>
<td>239</td>
</tr>
</tbody>
</table>

*Table 6.6: The numbers of respondents on the questionnaire in 10 days*
Several respondents when providing their personal details misunderstood their study levels using the UK system. For example, two respondents who chose their education as ‘higher study’, wrote that their studies were up to ‘National Diploma’ and ‘HND Elec’ or ‘Higher National Diploma in electrical engineering’. These study levels are the same level as college, but they selected the education category ‘Higher Study’ which relates to university degree. Some respondents gave other abbreviations in the higher study (university and above) category - such as BSc. Podiatry, CEng (it means Chemical Engineering), degree, graduate, RIBA (it means Royal Institute of British Architects) and UNIV (it means university), when they are actually undergraduate level in the UK. The respondents who categorised their higher degrees such as master, MSc, research and PhD are in the postgraduate level. Further, the study levels of two respondents needed clarification. One respondent wrote ‘Not from school’ but put this in the mixed degree category. The second respondent was in the age bracket 20-29 years old, British and living in the UK for 25 years. His learning support assistant wrote his entry as degree in adult social care. Judging by his age and his period of living in the UK, it might be more accurate to adjust his study level of the adult social care to college level rather than degree. Also the educational levels did not relate directly to the age of respondents because some of them were older visitors who graduated from primary and secondary levels many years ago.

For an acceptable response rate, IAR (2013) recommended high survey completion rates (80% or more) that could represent target population. The statistical calculation of the response rate in the survey was generated by taking the number of completed surveys and dividing this number by the number of people who took a questionnaire (300 copies) and multiplying by 100. 212 visitors responded (100 males and 112 females), representing all educational levels starting from primary school, going through secondary school, college and to postgraduate level. Hence, the percentage of the completed survey in terms of all the educational levels in this case study is (212x100)/300 = 70.67%. In addition, 27 respondents (14 males and 13 females) or 9 % did not represent their education backgrounds as N/A or mixed degree.
The Ethnicity website (2009) reported that the size of ethnic groups from the Information of Office for National Statistics in 2009 (for the total population in England and Wales of 54,809,000 people), is composed of White 87.9 %, Mixed 1.8%, Asian or Asian British 5.9%, Black or Black British 2.8%, Chinese and other ethnic group 1.6%. The table below compares expected and actual percentages of ethnic groups.

<table>
<thead>
<tr>
<th>Ethnic group</th>
<th>The numbers of the sampling from calculations</th>
<th>The numbers of the sampling at the museum</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: White</td>
<td>$\frac{(87.9 \times 212)}{100} = 186.4$</td>
<td>178</td>
</tr>
<tr>
<td>B: Mixed</td>
<td>$\frac{(1.8 \times 212)}{100} = 3.8$</td>
<td>4</td>
</tr>
<tr>
<td>C: Asian or Asian British</td>
<td>$\frac{(5.9 \times 212)}{100} = 12.5$</td>
<td>22</td>
</tr>
<tr>
<td>D: Black or Black British</td>
<td>$\frac{(2.8 \times 212)}{100} = 5.9$</td>
<td>2</td>
</tr>
<tr>
<td>E: Chinese or other ethnic</td>
<td>$\frac{(1.6 \times 212)}{100} = 3.4$</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>212</td>
<td>212</td>
</tr>
</tbody>
</table>

Table 6.7: The numbers of ethnic group

In this case study, the majority groups of educational levels were divided into four groups - primary school, secondary school, college and further education.
The paper-based questionnaire required the respondents to provide statements about their user experience if they used these three exhibits. It was found that the ‘Gravity Well’ exhibit generated the most responses of any exhibit (42.35%) which was visited by the respondents. The ‘Big Bang’ and ‘Getting the picture’ exhibit were the next two exhibits in terms of level of user interactions. The following examples illustrate the user experience.

- “A force that had everthings to the ground. I came with school 2 years ago and used it.” (no.231, female, under 20 years old, secondary school, studying, White, British, 14 years living in the UK).

- “ATTRACTION OF MASS TO MASS OVER DISTANCE (IN TESCO - WITH CHILDREN)”. (no.226, male, 40-49 years old, college, working, British, 43 years living in the UK). This respondent’s user experience is the similar to the exhibit ‘Gravity Well’ in the Tesco supermarket.
6.6.3 The results of the pre- and post-test paper-based questionnaire

The two main results of investigating cultural issues – language issues and conceptual understanding – using the pre- and post-test paper-based questionnaires are described as follows.

[1] The result of the investigation into the language issues

In the following figures, the graphs relate to the three scientific words identified in the language issues. The X axis is ethnic groups at each educational level and the Y axis is the level of understanding of the respondents. These results demonstrate:

- There are different levels of understanding with the three scientific words, due to differences between Pre- and Post-Test results when using these three ISTEs.

- The different levels of understanding in the three scientific words are due to ethnic groups or cultural background.

- The levels of understanding associated with these scientific words for ethnic group A (White) increase as the educational level increases - primary, secondary, college, and further education.

- Ethnic group B (Mixed) and group D (Black or Black British) have a small number of respondents (less than 5). This did not represent a sufficient sample for the statistical tests. Ethnic group C (Asian or Asian British) shows good sample size for the secondary and further education category. Ethnic group E, n = 6 (Asian or other ethnic group) also shows a small sample size in the further education category.
Figure 6.9: The line graph of the level of understanding for the word ‘Gravity’ based on the ethnic groups (A: White, B: Mixed, C: Asian or Asian British, D: Black or Black British, and E: Chinese or other ethnic group)

Figure 6.10: The line graph of the level of understanding for the word ‘Particle’ based on the ethnic groups (A: White, B: Mixed, C: Asian or Asian British, D: Black or Black British, and E: Chinese or other ethnic group)
Figure 6.11: The line graph of the level of understanding for the word ‘Focus’ based on the ethnic groups (A: White, B: Mixed, C: Asian or Asian British, D: Black or Black British, and E: Chinese or other ethnic group)
The Wilcoxon nonparametric test of ranks was used to investigate two experimental conditions (pre- and post-test) for the level of understanding of individuals in each ethnic group, at the same level of education.

Table 6.9: The results of a statistic test using 'Wilcoxon' for the pre- and post-test of the language issues

Table 6.9 shows that comparing pre- and post-test for Ethnic group A (n = 178) with secondary (n = 45), college (n = 33) and further education (n = 87), for each of these levels of education there is statistically significant difference in understanding of the word ‘Gravity’. Also this group has significant difference between pre- and post-test for college (n = 33) and further education (n = 87) levels of education, for understanding of the word ‘Focus’.

<table>
<thead>
<tr>
<th>Ethnic groups</th>
<th>Levels of education</th>
<th>Scientific words</th>
<th>Wilcoxon Test for the pre- and post-test of the language issues scored by the researcher</th>
<th>Results between pre- and post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Test statistic (Z-test)</td>
<td>Statistical significance ( \rho ) (2-tailed)</td>
</tr>
<tr>
<td>A: White (n = 178)</td>
<td>Primary (n = 13)</td>
<td>Gravity</td>
<td>-1.732&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.083</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Particle</td>
<td>-1.841&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.066</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Focus</td>
<td>0.000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.000</td>
</tr>
<tr>
<td>Secondary (n = 45)</td>
<td>Gravity</td>
<td>-3.500&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.000</td>
<td>Different</td>
</tr>
<tr>
<td></td>
<td>Particle</td>
<td>-0.931&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.352</td>
<td>No sig. diff.</td>
</tr>
<tr>
<td></td>
<td>Focus</td>
<td>-1.698&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.090</td>
<td>No sig. diff.</td>
</tr>
<tr>
<td>College (n = 33)</td>
<td>Gravity</td>
<td>-2.333&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.020</td>
<td>Different</td>
</tr>
<tr>
<td></td>
<td>Particle</td>
<td>-1.137&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.256</td>
<td>No sig. diff.</td>
</tr>
<tr>
<td></td>
<td>Focus</td>
<td>-2.543&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.011</td>
<td>Different</td>
</tr>
<tr>
<td>Further education (n = 87)</td>
<td>Gravity</td>
<td>-4.726&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.000</td>
<td>Different</td>
</tr>
<tr>
<td></td>
<td>Particle</td>
<td>-1.503&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.133</td>
<td>No sig. diff.</td>
</tr>
<tr>
<td></td>
<td>Focus</td>
<td>-3.741&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.000</td>
<td>Different</td>
</tr>
<tr>
<td>C: Asian or Asian British (n = 22)</td>
<td>Secondary (n = 6)</td>
<td>Gravity</td>
<td>-0.736&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.461</td>
</tr>
<tr>
<td></td>
<td>Particle</td>
<td>-1.000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.317</td>
<td>No sig. diff.</td>
</tr>
<tr>
<td></td>
<td>Focus</td>
<td>-1.604&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.109</td>
<td>No sig. diff.</td>
</tr>
<tr>
<td>Further Education (n = 11)</td>
<td>Gravity</td>
<td>-1.414&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.157</td>
<td>No sig. diff.</td>
</tr>
<tr>
<td></td>
<td>Particle</td>
<td>-0.378&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.705</td>
<td>No sig. diff.</td>
</tr>
<tr>
<td></td>
<td>Focus</td>
<td>-1.000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.317</td>
<td>No sig. diff.</td>
</tr>
<tr>
<td>E: Chinese or other group (n = 6)</td>
<td>Further Education (n = 5)</td>
<td>Gravity</td>
<td>-1.000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.317</td>
</tr>
<tr>
<td></td>
<td>Particle</td>
<td>-1.414&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.157</td>
<td>No sig. diff.</td>
</tr>
<tr>
<td></td>
<td>Focus</td>
<td>0.000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.000</td>
<td>No sig. diff.</td>
</tr>
</tbody>
</table>
The Mann Whitney U nonparametric test was used for comparison of the pre-test scores for the scientific words between different ethnic groups.

<table>
<thead>
<tr>
<th>Compare between ethnic groups</th>
<th>Levels of education</th>
<th>Scientific words</th>
<th>Mann-Whitney U Test for the ‘pre-test’ of the language issues scored by the researcher</th>
<th>Results of the ‘pre-test’</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: White (n = 178) and C: Asian or Asian British (n = 22)</td>
<td>Secondary (n_A = 45; n_C = 6)</td>
<td>Gravity</td>
<td>m_A = 26.22 m_C = 24.33</td>
<td>Mean rank (m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Particle</td>
<td>m_A = 26.33 m_C = 23.50</td>
<td>-0.470</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Focus</td>
<td>m_A = 27.02 m_C = 18.33</td>
<td>-1.422</td>
</tr>
<tr>
<td></td>
<td>Further Education (n_A = 87; n_C = 11)</td>
<td>Gravity</td>
<td>m_A = 51.30 m_C = 35.23</td>
<td>-2.089</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Particle</td>
<td>m_A = 50.47 m_C = 41.86</td>
<td>-1.014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Focus</td>
<td>m_A = 49.59 m_C = 48.77</td>
<td>-0.097</td>
</tr>
<tr>
<td>A: White (n = 178) and E: Chinese or other ethnic group (n = 6)</td>
<td>Further Education (n_A = 87; n_E = 5)</td>
<td>Gravity</td>
<td>m_A = 45.95 m_C = 56.00</td>
<td>-0.986</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Particle</td>
<td>m_A = 47.03 m_C = 37.20</td>
<td>-0.858</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Focus</td>
<td>m_A = 46.72 m_E = 42.70</td>
<td>-0.354</td>
</tr>
<tr>
<td>C: Asian or Asian British (n = 22) and E: Chinese or other ethnic group (n = 6)</td>
<td>Further Education (n_C = 11; n_E = 5)</td>
<td>Gravity</td>
<td>m_C = 7.09 m_E = 11.60</td>
<td>-2.038</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Particle</td>
<td>m_C = 8.68 m_E = 8.10</td>
<td>-0.240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Focus</td>
<td>m_C = 8.68 m_E = 8.10</td>
<td>-0.244</td>
</tr>
</tbody>
</table>

Table 6.10: The results of a statistical test using the ‘Mann Whitney U-Test’ on ‘pre-test’ scores of the three scientific words and the comparison with the different ethnic groups

Table 6.10 highlights that for pre-test, comparing ethnic group A (n = 178) and group C (n = 22) in further education (n_A = 87; n_C = 11) shows statistically significant difference in understanding of the word ‘Gravity’. Similarly, comparison of Ethnic group C: (n = 22) and group E (n = 6) in
further education \((n_C = 11; n_E = 5)\) shows significant differences in understanding of the word ‘Gravity’.

<table>
<thead>
<tr>
<th>Compare between ethnic groups</th>
<th>Levels of education</th>
<th>Scientific words</th>
<th>Mann-Whitney U Test for the ‘post-test’ of the language issues scored by the researcher</th>
<th>Results of the ‘post-test’</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean rank ((m))</td>
<td>Test statistic ((Z\text{-test}))</td>
</tr>
<tr>
<td>A: White ((n = 178)) and C: Asian or Asian British ((n = 22))</td>
<td>Secondary ((n_A = 45; n_C = 6))</td>
<td>Gravity</td>
<td>(m_A = 25.64) (m_C = 28.67)</td>
<td>-0.542</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Particle</td>
<td>(m_A = 26.21) (m_C = 24.42)</td>
<td>-0.295</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Focus</td>
<td>(m_A = 25.89) (m_C = 26.83)</td>
<td>-0.153</td>
</tr>
<tr>
<td></td>
<td>Further Education ((n_A = 87; n_C = 11))</td>
<td>Gravity</td>
<td>(m_A = 51.50) (m_C = 33.68)</td>
<td>-2.114</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Particle</td>
<td>(m_A = 50.52) (m_C = 41.45)</td>
<td>-1.111</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Focus</td>
<td>(m_A = 49.90) (m_C = 46.36)</td>
<td>-0.429</td>
</tr>
<tr>
<td>A: White ((n = 178)) and E: Chinese or other ethnic group ((n = 6))</td>
<td>Further Education ((n_A = 87; n_E = 5))</td>
<td>Gravity</td>
<td>(m_A = 46.24) (m_C = 51.10)</td>
<td>-0.433</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Particle</td>
<td>(m_A = 46.49) (m_E = 46.60)</td>
<td>-0.010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Focus</td>
<td>(m_A = 47.19) (m_E = 34.50)</td>
<td>-1.133</td>
</tr>
<tr>
<td>C: Asian or Asian British ((n = 22)) and E: Chinese or other ethnic group ((n = 6))</td>
<td>Further Education ((n_C = 11; n_E = 5))</td>
<td>Gravity</td>
<td>(m_C = 7.27) (m_E = 11.20)</td>
<td>-1.623</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Particle</td>
<td>(m_C = 8.14) (m_E = 9.30)</td>
<td>-0.469</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Focus</td>
<td>(m_C = 9.05) (m_E = 7.30)</td>
<td>-0.756</td>
</tr>
</tbody>
</table>

Table 6.11: The results of a statistical analysis using the ‘Mann-Whitney U test’, for the ‘post-test’ of the three scientific words and the comparison with the different ethnic groups

Table 6.11 highlights that for post-test, comparing Ethnic group A \((n = 178)\) and group C \((n = 22)\) in further education \((n_A = 87; n_C =11)\) shows statistically significant difference in understanding of the word ‘Gravity’.

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[2] The result of conceptual understanding

The following figures display graphs relating to the three exhibits identified as significant in the conceptual understanding of the three exhibits. The X axis is ethnic groups at each educational level and the Y axis is the level of understanding of the respondents. These results demonstrate:

- The levels of understanding (mean) in the conceptual understanding of the three exhibits in ethnic group A (White) increase as the educational level increases.
- The levels of understanding change (but do not always increase) due to ethnic groups or cultural background.
- The ethnic groups have different scores based on their self-assessment score and the scoring generated by the author.
- Ethnic group B (Mixed) and group D (Black or Black British) have only a few respondents (less than 5) which did not represent a sufficient sample for statistical tests. Ethnic group C (Asian or Asian British) had sufficient sample size for secondary and further education. Ethnic group E (Asian or other ethnic group) had sufficient sample in the further education category.

Figure 6.12: The line graph of the level of understanding for the ‘Gravity well’ exhibit based on the ethnic groups (A: White, B: Mixed, C: Asian or Asian British, D: Black or Black British, and E: Chinese or other ethnic group)
Figure 6.13: The line graph of the level of understanding for the ‘Big Bang’ exhibit based on the ethnic groups (A: White, B: Mixed, C: Asian or Asian British, D: Black or Black British, and E: Chinese or other ethnic group)

Figure 6.14: The line graph of the level of understanding for the ‘Getting the picture’ exhibit based on the ethnic groups (A: White, B: Mixed, C: Asian or Asian British, D: Black or Black British, and E: Chinese or other ethnic group)
<table>
<thead>
<tr>
<th>Ethnic groups</th>
<th>Levels of education</th>
<th>ISTEs</th>
<th>Wilcoxon Test for the difference in conceptual understanding between scored by the researcher and self-assessment</th>
<th>Comparison of results scored by self-assessment with and by the researchers’ assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: White</td>
<td>Primary (n = 13)</td>
<td>Gravity Well</td>
<td>-2.414&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>-2.232&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>-2.226&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>Secondary (n = 45)</td>
<td>Gravity Well</td>
<td>-3.727&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>-4.554&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>-4.514&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>College (n = 33)</td>
<td>Gravity Well</td>
<td>-3.792&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>-2.914&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>-3.334&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Further education (n = 87)</td>
<td>Gravity Well</td>
<td>-5.265&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>-5.353&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>-5.564&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.000</td>
</tr>
<tr>
<td>C: Asian or Asian British (n = 22)</td>
<td>Secondary (n = 6)</td>
<td>Gravity Well</td>
<td>-1.518&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.129</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>-2.060&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.039</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>-2.041&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>Further Education (n = 11)</td>
<td>Gravity Well</td>
<td>-2.388&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.017</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>-2.041&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>-2.232&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.026</td>
</tr>
<tr>
<td>E: Chinese or other ethnic group (n = 6)</td>
<td>Further Education (n = 5)</td>
<td>Gravity Well</td>
<td>-1.000&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.317</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>-1.289&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.197</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>-1.633&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.102</td>
</tr>
</tbody>
</table>

Table 6.12: The results of a statistical analysis using ‘Wilcoxon test’, for comparison of conceptual understanding scored by the researcher and self-assessment.
<table>
<thead>
<tr>
<th>Compare between ethnic groups</th>
<th>Levels of education</th>
<th>ISTEes</th>
<th>Mann-Whitney U Test for the 'pre-test' of the conceptual understanding scored by self-assessment</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean rank (m)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Test statistic (Z-test)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Statistical significance $\rho$ (2-tailed)</td>
<td></td>
</tr>
<tr>
<td>A: White (n = 178) and C: Asian or Asian British (n = 22)</td>
<td>Secondary (n$_A$ = 45; n$_C$ = 6)</td>
<td>Gravity Well</td>
<td>$m_A = 26.11$ $m_C = 25.17$ $-0.150$ 0.881 No sig. diff.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>$m_A = 27.00$ $m_C = 18.50$ $-1.346$ 0.178 No sig. diff.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>$m_A = 26.41$ $m_C = 22.92$ $-0.558$ 0.577 No sig. diff.</td>
<td></td>
</tr>
<tr>
<td>A: White (n = 178) and E: Chinese or other ethnic group (n = 6)</td>
<td>Further Education (n$_A$ = 87; n$_C$ = 11)</td>
<td>Gravity Well</td>
<td>$m_A = 49.51$ $m_C = 49.41$ $-0.012$ 0.991 No sig. diff.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>$m_A = 49.80$ $m_C = 47.14$ $-0.304$ 0.761 No sig. diff.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>$m_A = 48.41$ $m_C = 58.09$ $-1.104$ 0.269 No sig. diff.</td>
<td></td>
</tr>
<tr>
<td>A: White (n = 178) and E: Chinese or other ethnic group (n = 6)</td>
<td>Further Education (n$_A$ = 87; n$_E$ = 5)</td>
<td>Gravity Well</td>
<td>$m_A = 46.48$ $m_C = 46.90$ $-0.037$ 0.971 No sig. diff.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>$m_A = 46.67$ $m_E = 43.50$ $-0.269$ 0.788 No sig. diff.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>$m_A = 45.80$ $m_E = 58.70$ $-1.097$ 0.273 No sig. diff.</td>
<td></td>
</tr>
<tr>
<td>C: Asian or Asian British (n = 22) and E: Chinese or other ethnic group (n = 6)</td>
<td>Further Education (n$_C$ = 11; n$_E$ = 5)</td>
<td>Gravity Well</td>
<td>$m_C = 8.41$ $m_E = 8.70$ $-0.116$ 0.907 No sig. diff.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>$m_C = 8.50$ $m_E = 8.50$ $0.000$ 1.000 No sig. diff.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>$m_C = 8.32$ $m_E = 8.90$ $-0.237$ 0.813 No sig. diff.</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.13: The results of a statistical analysis using ‘Mann-Whitney U test’, for the pre-test of the conceptual understanding of the three exhibits scored by self-assessment and compare between the different ethnic groups

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### Table 6.14: The results of a statistical analysis using ‘Mann-Whitney U test’, for the comparison between different ethnic groups of post-test of the conceptual understanding of the three exhibits scored by the researcher

<table>
<thead>
<tr>
<th>Compare between ethnic groups</th>
<th>Levels of education</th>
<th>ISTE</th>
<th>Mann-Whitney U Test for the ‘post-test’ of the conceptual understanding scored by the researcher</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean rank (m)</td>
<td>Test statistic (Z-test)</td>
</tr>
<tr>
<td>A: White (n = 178) and C: Asian or Asian British (n = 22)</td>
<td>Secondary ((n_A = 45; n_C = 6))</td>
<td>Gravity Well</td>
<td>(m_A = 26.01) (m_C = 25.92)</td>
<td>-0.016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>(m_A = 27.00) (m_C = 18.50)</td>
<td>-1.414</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>(m_A = 26.64) (m_C = 21.17)</td>
<td>-0.940</td>
</tr>
<tr>
<td></td>
<td>Further Education ((n_A = 87; n_C = 11))</td>
<td>Gravity Well</td>
<td>(m_A = 51.89) (m_C = 30.64)</td>
<td>-2.516</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>(m_A = 51.15) (m_C = 36.45)</td>
<td>-1.680</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>(m_A = 49.79) (m_C = 47.18)</td>
<td>-0.313</td>
</tr>
<tr>
<td>A: White (n = 178) and E: Chinese or other ethnic group (n = 6)</td>
<td>Further Education ((n_A = 87; n_E = 5))</td>
<td>Gravity Well</td>
<td>(m_A = 46.08) (m_C = 53.80)</td>
<td>-0.684</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>(m_A = 46.75) (m_E = 42.20)</td>
<td>-0.386</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>(m_A = 46.30) (m_E = 49.90)</td>
<td>-0.324</td>
</tr>
<tr>
<td>C: Asian or Asian British (n = 22) and E: Chinese or other ethnic group (n = 6)</td>
<td>Further Education ((n_C = 11; n_E = 5))</td>
<td>Gravity Well</td>
<td>(m_C = 7.00) (m_E = 11.80)</td>
<td>-1.990</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big Bang</td>
<td>(m_C = 8.09) (m_E = 9.40)</td>
<td>-0.533</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Getting the picture</td>
<td>(m_C = 8.18) (m_E = 9.20)</td>
<td>-0.439</td>
</tr>
</tbody>
</table>
In addition, the results from the post-test questionnaire demonstrated considerable effects of several dimensions of the cultural issues. For example, language issues, conceptual understanding, visual cultures and emotional values as follows:

- **Language issues**: most respondents who studied at higher education level used several scientific words to support their explanations of the three scientific words - gravity, particle, and focus. For example, using the word ‘force’ when explaining the meaning of gravity. However, some respondents who were in lower education used the word ‘thing’ to represent the word ‘force’.

- **Conceptual understanding**: it was discovered that three respondents had different conceptual understandings about the Big Bang which came from their religious backgrounds and religious beliefs in the following table.

<table>
<thead>
<tr>
<th>Date</th>
<th>No.</th>
<th>Gender</th>
<th>Personal backgrounds</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>14/03/2013</td>
<td>33</td>
<td>Female</td>
<td>Age ranges Under 20</td>
<td>“I don't believe in the Big Bang God created the world.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Study level Secondary School</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Employment Study</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Major ethnic Black or Black British</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Minor ethnic Caribbean</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nationality Jamaica</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Country live in England</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>How long have you been staying in the UK? 10 years</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Country Born England</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>First language N/A</td>
<td></td>
</tr>
<tr>
<td>23/03/2013</td>
<td>167</td>
<td>Female</td>
<td>Age ranges 20-29</td>
<td>“It’s a lie, - God created the earth in 7 days and then eve ate the apple + it all went wrong.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Study level Undergraduate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Employment Working</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Major ethnic Asian or Asian British</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Minor ethnic N/A</td>
<td></td>
</tr>
</tbody>
</table>
Table 6.15: Altered conceptual understanding appearing in the questionnaire

- **Visual cultures:** this survey did not require any drawing to fill in the questionnaire, the visual cultures occurred on the pre-test and post-test questionnaire, which consisted of five images from the five respondents shown in the following table.
<table>
<thead>
<tr>
<th>Date</th>
<th>ID</th>
<th>Age</th>
<th>Gender</th>
<th>Age ranges</th>
<th>Study level</th>
<th>Employment</th>
<th>Major ethnic</th>
<th>Minor ethnic</th>
<th>Nationality</th>
<th>Country live in</th>
<th>How long have you been staying in the UK?</th>
<th>Country Born</th>
<th>First language</th>
</tr>
</thead>
<tbody>
<tr>
<td>16/03/2013</td>
<td>67</td>
<td>Male</td>
<td></td>
<td>20-29</td>
<td>Postgraduate</td>
<td>Working</td>
<td>White</td>
<td>British</td>
<td>British</td>
<td>England</td>
<td>25 years</td>
<td></td>
<td>English</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The post-test: this shows how well the visitor understands the ‘Gravity Well’ exhibit which he described as “Objects orbit a Cylindrical Shape and the momentum pulls them towards the Centre” with the image as follows.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>Female</td>
<td>Age ranges</td>
<td>20-29</td>
<td>Study level</td>
<td>Postgraduate</td>
<td>Employment</td>
<td>Major ethnic</td>
<td>Minor ethnic</td>
<td>Nationality</td>
<td>Country live in</td>
<td>How long have you been staying in the UK?</td>
<td>Country Born</td>
<td>First language</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Chinese or other ethnic group</td>
<td>Chinese</td>
<td>Malaysian</td>
<td>UK</td>
<td>11 years</td>
<td></td>
<td>England</td>
</tr>
<tr>
<td>3/2013</td>
<td>167</td>
<td>Female</td>
<td>Age ranges</td>
<td>20-29</td>
<td>Undergraduate</td>
<td>Working</td>
<td>Major ethnic</td>
<td>Minor ethnic</td>
<td>Nationality</td>
<td>Country live in</td>
<td>How long have you been staying in the UK?</td>
<td>Country Born</td>
<td>First language</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Asian or Asian British</td>
<td>N/A</td>
<td>British</td>
<td>England</td>
<td>25 years</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6.16: Visual cultures were found in the questionnaire

<table>
<thead>
<tr>
<th>Country Born</th>
<th>England</th>
</tr>
</thead>
<tbody>
<tr>
<td>First language</td>
<td>Gujarati</td>
</tr>
</tbody>
</table>

| Age ranges | 20-29 |
| Study level  | Postgraduate |
| Employment   | Unemployed |
| Major ethnic | White |
| Minor ethnic | British |
| Nationality  | Welsh |
| Country live in | Wales |
| How long have you been staying in the UK? | 0.5 year |
| Country Born | Wales |
| First language | English |

The post-test, how well the visitor understands the ‘Gravity Well’ exhibit where he described that “Ultimately, the orbits will decay as the effect F Hand is decreased by friction, would be curious to try with smooth balls too.” with the image as follows.
- **Emotional values**: Emotional values were explored in the answers relating to two exhibits on the post-test: how well do they understand the ‘Big Bang’ and ‘Getting the picture’ exhibits. The five respondents expressed their emotional values, highlighted in green in the questionnaire as the following table.

<table>
<thead>
<tr>
<th>Date</th>
<th>No.</th>
<th>Gender</th>
<th>Personal backgrounds</th>
<th>Expressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>13/03/2013</td>
<td>5</td>
<td>Female</td>
<td>Age ranges: 20-29</td>
<td>In the post-test of how well the visitor understand the ‘Big Bang’ exhibit: “It didn’t work, <strong>sorry</strong>.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Study level: N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Employment: Working</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Major ethnic: White</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Minor ethnic: British</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nationality: English</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Country live in: England</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>How long have you been staying in the UK?: 20 years</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Country Born: England</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>First language: English</td>
<td></td>
</tr>
<tr>
<td>16/03/2013</td>
<td>54</td>
<td>Female</td>
<td>Age ranges: 40-49</td>
<td>In the post-test of how well the visitor understand the ‘Big Bang’ exhibit: <strong>great fun - but no info !</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Study level: N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Employment: Working</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Major ethnic: White</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Minor ethnic: British</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nationality: British</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Country live in: UK</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>How long have you been staying in the UK?: 49</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Country Born: UK</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>First language: English</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>Female</td>
<td>Age ranges: 30-39</td>
<td>In the post-test of how well the visitor understand the ‘Big Bang’ exhibit: “I wasn't sure, but <strong>It was fun !</strong> Is it supposed to say that</td>
<td></td>
</tr>
</tbody>
</table>
In the post-test of how well the visitor understand the ‘Big Bang’ exhibit: “don't understand - funny!”

In the post-test of how well the visitor understand the “Getting the picture’ exhibit: ‘Not sure about the whole purpose but we enjoyed experimentery together but needs more of a look to space exploration”

<table>
<thead>
<tr>
<th>Country live in</th>
<th>Britain</th>
<th>How long have you been staying in the UK?</th>
<th>33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country Born</td>
<td>Britain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First language</td>
<td>English</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23/03/2013</td>
<td>162</td>
<td>Age ranges</td>
<td>40-49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Study level</td>
<td>Postgraduate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Employment</td>
<td>Working</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Major ethnic</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minor ethnic</td>
<td>British</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nationality</td>
<td>British</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Country live in</td>
<td>England</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How long have you been staying in the UK?</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Country Born</td>
<td>England</td>
</tr>
<tr>
<td></td>
<td></td>
<td>First language</td>
<td>English</td>
</tr>
</tbody>
</table>

| 25/03/2013      | 217     | Age ranges                               | 40-49 |
|                 |         | Study level                               | Undergraduate |
|                 |         | Employment                                | Working |
|                 |         | Major ethnic                              | White |
|                 |         | Minor ethnic                              | British |
|                 |         | Nationality                               | British |
|                 |         | Country live in                           | England |
|                 |         | How long have you been staying in the UK? | 41 |
|                 |         | Country Born                              | England |
|                 |         | First language                            | English |

Table 6.17: Emotional values in the questionnaire
6.6.4 The results of video recording and observations
Fifty nine video clips were recorded of sample respondents’ interactions. Most video clips could not be heard clearly on play back because the multimedia sound effects on the big digital screen beside the ‘Big Bang’ exhibit were very loud within the ‘Exploring the Universe’ gallery and masked the voices of the respondents’ communications. The three examples of video-thumbnails are as follows:

Figure 6.15: Example of a short video clip shows the lady sitting on a wheelchair interacting with the ‘Gravity well’ exhibit
[This video (no.4) was recorded by getting permission of the family - a mother sitting in a wheelchair and a daughter - on the ethical clearance form]
Figure 6.16: Example of a short video clip shows the family group interacting with the ‘Big Bang’ exhibit

[This video (no.56) was recorded by getting permission of the family – parents and a daughter - on the ethical clearance form]
Figure 6.17: Example of a short video clip shows the family group interacting with ‘Getting the picture’ exhibit
[This video (no.38) was recorded by getting permission of the family – parents and two daughters - on the ethical clearance form]
These video clips were examined in terms of respondents’ interactions relating to the dimensions of the cultural issues. In the following table, several video clips had many interactions which had the same patterns. In addition, the results of the video clips often highlighted more than one cultural issue. For example, video clip no.14 appeared in two cultural dimensions - physical skills and visual cultures.

<table>
<thead>
<tr>
<th>The 10 dimensions of the cultural issues</th>
<th>Interactions’ results</th>
<th>The numbers of the videos</th>
<th>The recorded dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Physical skills</td>
<td><strong>Learning by trying at the beginning:</strong> Most respondents initially start by experimenting on the exhibits. Then if they could not find how to use their physical skills to handle the exhibits, they might read and follow the exhibits’ instructions on the graphic panel later. For example, the respondents try to use their hands to manipulate the ‘Getting the picture’, ‘Big Bang’ and ‘Gravity Well’ Exhibit.</td>
<td><strong>2 videos</strong> [no.14 (0.17 sec.clip), no.15 (0.20 sec.clip)]</td>
<td><strong>15/03/2013</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Trying many options:</strong> Four respondents in a family group interacted with the ‘Gravity Well’ exhibit in various ways, such as the mother threw a ball down to a hole, the first girl rotated a ball from the left to the hole, the father spun a ball from the right and the second girl threw a ball up and drop it down into the cavity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Trying until almost successful:</strong> A young Asian boy came with his family to try to speed a disc on</td>
<td><strong>1 video</strong> [no.36 (0.17 sec.clip)]</td>
<td><strong>24/03/2013</strong></td>
</tr>
</tbody>
</table>

|                                        | **2 videos** [no.21 (0.09 sec.clip), no.22 (0.24 sec.clip)] | | **17/03/2013** |
|                                        | | | |
1. Physical skills
(continued)

the ‘Big Bang’ exhibit. He did not read the instruction on the exhibit and tried to spin the disc until the particles moved around and he launched it, but the lady opposite him could not spin the particle fast enough. Hence, this family could not see scattering particles on the ‘Big Bang’ exhibit. In another case, many respondents tried to speed a disc on the ‘Big Bang’ exhibit very fast. But their participant - a young girl could only generate a slow speed with her disc.

**Trying until success:**
The respondents turned a disc in the ‘Big Bang’ exhibit very fast and then launched the particles jointly. They could see the particles scattering on the table of the Big Bang exhibit.

**Missing interaction will stop learning and not promote understanding:**
Two respondents could not use their hands to quickly rotate a disc on the ‘Big Bang’ exhibit, and so it failed to demonstrate particles scattering. Then they left the exhibit.
<table>
<thead>
<tr>
<th></th>
<th>Physical skills (continued)</th>
<th>Using different skills to handle:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A respondent who came with his family and participated with a young daughter on the ‘Big Bang’ exhibit. He changed from his right hand to use his left hand to rotate a disc and then he used his right hand to grab a corner of the ‘Big Bang’ exhibit’s table.</td>
<td>1 video [no.55 (0.29 sec.clip)] 24/03/2013</td>
</tr>
<tr>
<td></td>
<td>2. Technologies issues</td>
<td>Unable to control:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Several respondents could not spin the discs fast enough - adults, young teenagers and children. Consequently, they could not investigate of understand the technologies issues being addressed by this exhibit.</td>
<td>1 video [no.18 (0.11 sec.clip)] 16/03/2013</td>
</tr>
<tr>
<td></td>
<td>3. Language issues</td>
<td>Reading with following:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The respondents first saw the information describing the exhibit found after spending time on this. They tried to interact with the exhibit, following the description on the board e.g. the ‘Gravity Well’ exhibit.</td>
<td>1 video [no.33 (1.07 sec.clip)] 17/03/2013</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reading and then changing their actions:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The respondents in the family group changed their interactions from the fading hand images of the ‘Getting the picture’ exhibit. They then read the display board and followed the actions described on the text. Hence, the respondents aimed to start by touching the bottom dish because the graphic panel states ‘Place your hand, palm facing downwards, on the bottom dish’.</td>
<td>1 video [no.53 (0.18 sec.clip)] 24/03/2013</td>
</tr>
<tr>
<td>3. Language issues (continued)</td>
<td>However, this text is contradicted by the visual image which portrays the hand starting in the middle of the dish.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Visual cultures</td>
<td><strong>Watching and copying the interaction from the image:</strong> Many respondents such as friends and family groups viewed the text on the graphic panel of the ‘Getting the picture’ exhibit. This showed a drawing of many hands fading from darker to lighter as the hand move up and down. The respondents having looked at the hand pictures on this board followed its example and started to touch at the deepest point of the parabolic dish, like the image of the fading hand and then lifted both of their hands up to find the focal point of the hot spot.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>3 videos</strong> [no.1 (0.02 sec.clip), no.14 (0.17 sec.clip), no.16 (0.34 sec.clip)] 15/03/2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>1 video</strong> [no.23 (0.14 sec.clip)] 16/03/2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Watching and adapting the interaction by the change in the image:</strong> Several respondents came with their family and looked at the hand images of the ‘Getting the picture’ exhibit. They tried to follow the instructions on the graphic panel. With the smaller children, the natural positions of their outstretched hands were at the level of the bottom of the lower dish. They then had the idea to put their hands on the lowest part of the dish, and moved their hand upward-toward an electric lamp on the top of the second dish.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>6 videos</strong> [no.37 (0.20 sec.clip), no.38 (0.13 sec.clip), no.49 (0.50 sec.clip), no.53 (0.18 sec.clip), no.54 (0.25 sec.clip), no.59 (0.25 sec.clip)] 24/03/2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Conceptual understanding</td>
<td>This cultural issue could not be examined from the sample visitors’ video clips</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Social issues</td>
<td><strong>Learning from observing other people:</strong> The respondent who came with their partner, family or friends; they might watch, observe and then copy other participants to interact with the exhibits such as the ‘Big Bang’ exhibit.</td>
<td>1 video [no.18 (0.11 sec.clip)] 16/03/2013</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Crowding around the exhibits will cause non-interactions:</strong> Many respondents in the family groups might wait in a long queue at exhibits whilst other visitors fully interact with the exhibit. Hence, these groups of the respondents could not manipulate the exhibit and only viewed other visitors’ interactions. For example, several visitors stayed near the ‘Big Bang’ exhibit and watched others using the exhibit.</td>
<td>2 videos [no.43 (0.10 sec.clip), no.44 (0.06 sec.clip)] 24/03/2013</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Learning from discussing with other people:</strong> The respondent who came as a couple, with family or friends might like to talk and discuss with other groups e.g. these social issues were found at the ‘Gravity Well’ exhibit.</td>
<td>1 video [no.20 (0.11 sec.clip)] 16/03/2013</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Joining an interaction with another family or other groups:</strong> The respondents got an invitation to join with the people or family who were already using the exhibit; and this situation gave them a social interaction with</td>
<td>1 video [no.57 (0.23 sec.clip)] 24/03/2013</td>
<td></td>
</tr>
</tbody>
</table>
### Social issues

6. Social issues (continued)

Other people. For example, a young girl came and joined the ‘Gravity Well’ exhibit with the respondent’s family.

**Doing interactions alone might not promote discovery:**

Some exhibits such as the ‘Big Bang’ exhibit need a number of people for multiple interactions. A respondent who was a lady on her own interacted with the ‘Big Bang’ exhibit. She could not discover by herself how to make particles collide. Moreover, she read the instructions on the exhibit and turned a disc slowly.

<table>
<thead>
<tr>
<th>1 video [no.24](0.03 sec.clip)</th>
<th>16/03/2013</th>
</tr>
</thead>
</table>

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### Emotional values

7. Emotional values

**Face expressions after success:**

A couple of the respondents who succeeded in accessing and interacted with the ‘Big Bang’ exhibit, smiled when they saw the particles impacted.

<table>
<thead>
<tr>
<th>2 videos [no.9](0.02 sec.clip), [no.10](0.06 sec.clip)</th>
<th>15/03/2013</th>
</tr>
</thead>
</table>

**Body movements after success:**

One of the respondents succeeded in accessing and interacting with the ‘Big Bang’ exhibit. He lifted his hands and fingers up after the particles crashed.

<table>
<thead>
<tr>
<th>1 video [no.17](0.21 sec.clip)</th>
<th>16/03/2013</th>
</tr>
</thead>
</table>

**Voice expressions with body movements after success:**

A young girl and her mother got a collision of the particles in the ‘Big Bang’ exhibit and the girl shouted “Yeah” and lifted both her hands up.

<table>
<thead>
<tr>
<th>2 videos [no.46](0.06 sec.clip), [no.51](0.14 sec.clip)</th>
<th>24/03/2013</th>
</tr>
</thead>
</table>
### 7. Emotional values

*(continued)*

<table>
<thead>
<tr>
<th><strong>Face and voice expressions with body movements after success:</strong></th>
</tr>
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<tbody>
<tr>
<td>After the lady in the family group succeeded in causing a collision of the particles; she smiled, said “Hey”, and moved her hands in front of her body.</td>
</tr>
</tbody>
</table>

| 1 video [no.56](0.42 sec.clip) |
| 24/03/2013 |

<table>
<thead>
<tr>
<th><strong>Exclaim after no success:</strong></th>
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<tbody>
<tr>
<td>One of the respondents who could not make the particles hit together in the ‘Big Bang’ exhibit, cried out and said “Oh! It did not work”.</td>
</tr>
</tbody>
</table>

| 1 video [no.19](0.38 sec.clip) |
| 16/03/2013 |

### 8. Age issues

<table>
<thead>
<tr>
<th><strong>Harder for young children:</strong></th>
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<tbody>
<tr>
<td>Most young boys and girls who were respondents in a family group could not rotate a disc in the ‘Big Bang’ exhibit fast enough to show particles moving around the disc.</td>
</tr>
</tbody>
</table>

| 2 videos [no.40](0.08 sec.clip), [no.43](0.10 sec.clip) |
| 24/03/2013 |

<table>
<thead>
<tr>
<th><strong>Not performed by old people:</strong></th>
</tr>
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<tbody>
<tr>
<td>Most old people came with their partners or their family and just looked around and did not interact with some exhibits such as the ‘Big Bang’ exhibit. Observations of old persons were not recorded by the video clips because these old persons did not wish to become respondents.</td>
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</table>

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</table>

### 9. Gender issues

<table>
<thead>
<tr>
<th>No gender differences were found in interactions with the exhibits from the couples on the video clips</th>
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<tbody>
<tr>
<td>-</td>
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</tbody>
</table>

### 10. Disabled people

<table>
<thead>
<tr>
<th><strong>Not comfortable for disabled peoples’ interactions:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>There was only one disabled respondent. She was a mother</td>
</tr>
</tbody>
</table>

| 10 videos [no.2](0.02 sec.clip), [no.3](0.05 sec.clip), [no.4] |
| 15/03/2013 |
10. Disabled people

(continued)
sitting in a wheel chair being
looked after by her daughter.
Before taking the videos, they
were asked about their
relationship. The mother was
partially sighted because the
vision in one of her eyes was
defective. The exhibits were
described and explained to the
mother and discussed with her
daughter. Following this the
daughter wanted to turn the
wheel chair in a corner of the
exhibits, so her mother could be
moved into a convenient position
for reaching out her hand to grab
a small ball in the ‘Gravity Well’
exhibit and rotate a disc in the
‘Big Bang’ exhibit. On the
contrary, her mother could easily
interact with the ‘Getting the
picture’ exhibit - one side of the
wheel chair could pass under the
exhibit counter. In addition, her
daughter helped her mother to fill
in the questionnaire. All answers
were written down by the
daughter but the context was
provided entirely by the mother.

Table 6.18: The results from the video recorders and observations
6.7 Discussions

6.7.1 Experience outcomes:
The result of the user-experience reported was that the most usage of ISTEs occurred in the ‘Exploring the Universe’ gallery with the ‘Gravity well’ (42.35%), the ‘Big Bang’ (24.2%), and the ‘Getting the picture’ exhibit (22.99%). However, this is not the same as the definitions ‘attracting power’ and ‘holding power’ which originated from Robinson et al. (1928) and were reviewed recently by Macdonald (2006). Some visitors explained that they have seen a similar exhibit to the ‘Gravity well’ exhibit in other places e.g. museums and a shopping centre. In addition, the National Space Centre (2013b, para.1) pointed out that “Exploring the Universe uses technology in a more mysterious and hidden way to bring to life the wonders and mind-blowing aspects of our universe. ‘Where did we come from?’, ‘How did the Universe begin?’, ‘Is there anybody out there’. From black holes to backyard astronomy, this scientific area will work on two levels – one for those who want to ask questions, and one for those who just want to look”. This statement by the National Space Centre (2013b, para.1) relates to the user-experience in case study 3 and Roschelle’s (1995) viewpoint of prior knowledge in the experience of learners, and Anderson and Lucas’s (1997) recommendation regarding experience in learning processes at museums.

For the experience outcomes found in this research, visitors could be directly interested in the ISTEs when used by themselves, or when used with family or friends. Alternatively there could be experiences when a visitor has discussed an ISTE with other visitors. Any or all of these experiences may provide a more satisfying outcome than asking questions of museum staff, or just observing other visitors.

6.7.2 Learning outcomes:
Investigation of language issues reveals that respondents can achieve significantly higher average learning outcomes when they have studied at the ‘further educational’ level. For example, the Wilcoxon test in Table 6.9 demonstrates that ethnic group A (White) can increase their learning of the word ‘Gravity’ better than the other words ‘Particle’ and ‘Focus’ at the same
study levels. Similarly, the word ‘Focus’ was significantly different in ethnic group A (White) at the study levels – ‘College’ and ‘Further education’. This compares with ethnic group C (Asian or Asian British) and ethnic group E (Chinese or other ethnic group) where no significant difference is found in the statistic test in Table 6.9. Additionally, the respondents who used English as their first language, the same as the scientific words in English – had a significantly higher average learning outcome. This outcome was calculated from the average difference in scores between the pre-test and post-test scored. Better scores were produced for the particular scientific word, than those scores from people at a lower education level.

These learning outcomes may be caused by ‘cognitive mapping’ of experience prior to using ISTEs in the literature review. Piscitelli et al. (2003) asserted a viewpoint which originated with Tolman (1948). The respondents in the study from education levels – ‘Secondary’, ‘College’, and ‘Further education’ – have known the word ‘Gravity’ from their time in primary level schooling. The National Curriculum in the UK requires ‘Gravity’ to be taught to these pupils. However, they have not been taught ‘Particle’ and ‘Focus’ because they were not on the curriculum. In the case of both these words, it was therefore not surprising there was not a difference in these learning outcomes. Similarly, several respondents at the primary level from ethnic group A (White) and ethnic group C (Asian or Asian British) replied – “I don’t know”, and ‘N/A’. They did not know about the words ‘Particle’ and ‘Focus’, before they interacted with the ‘Big Bang’ and ‘Getting the picture’ exhibits.

The ‘Gravity Well’ and ‘Getting the picture’ exhibit – are categorised by the characteristic ‘complex understanding’ in the new classification proposed in this thesis. The respondents had increasing scores in learning outcomes (See Figure 6.12 and 6.14). That may be caused by the fact that these two exhibits have more space for visitors to observe each other, partners, family, and school groups. The ‘Big Bang’ exhibit did generate a lot of noise. This was at its loudest near to the screen monitor which observers had to be close to, in order to read the visual displays for the exhibits. This noise problem unfortunately prevented any chatting or discussion among the visitors. This
‘Big Bang’ exhibit was categorised in the ‘direct understanding’ category of the new classification. The ‘Big Bang’ exhibit also seems to generate increasing scores in learning outcomes (See Figure 6.13). For example, the results in Table 6.14 demonstrated that the post test of conceptual understanding of ‘Gravity Well’ for respondents from ethnic group A (White) and ethnic group E (Chinese or other ethnic group) who study at the ‘further education’ were higher than group C (Asian or Asian British).

The learning outcomes of the respondents in the conceptual understanding of these three ISTEs are similar to the Northern Ireland Curriculum (2007) perspective for school pupils when they are visitors at museums and learn scientific knowledge by using and interacting with ISTEs. However, the learning outcome as defined by Owen-Jackson’s (2007) viewpoint for school pupils in this case study 3 was established by visitors in the museums responding and providing their critical thinking in response to the paper-based survey. Further, it was found that visitors enhanced their learning outcomes by discussions with other visitors, which is Davidsson and Jakobsson’s (2012) viewpoint.

### 6.7.3 Understanding outcomes:

In this case study, ethnicity is an important factor in examining both learning and understanding of the respondents. Nevertheless, other factors e.g. the assessment of subjects, educational backgrounds, and the intelligence of each respondent - might influence the respondents’ learning and understanding but were not included in this exercise. This is because the essential inquiry via paper-based questionnaires needs to be brief for the respondents to reply within their limited time at the museum. Further, other cultural backgrounds such as official languages and religions may also affect the visitors’ understanding and learning of science on interactive science exhibits. For example, international visitors who might not have English as their first language could find it difficult to explain the meaning of the three scientific words – ‘Gravity’, ‘Particle’, and ‘Focus’ in English. But they might believe that they could describe the scientific words in their own language. Moreover, three respondents could not change their previous conceptual
idea because they were influenced by their religions - they believed in God’s creation rather than the Big Bang. Similar results were reported by Groves’s (1995) report on the scientific concepts and science vocabulary relating to students’ learning in school science where the visitors had graduated many years ago. They might forget the exact meaning of scientific vocabulary which they learnt years ago previously in their schools. Any new discovery of science may create a new scientific vocabulary for an individual. Such people may encounter these new scientific words for the first time when they visit museums.

Self-assessment of respondents estimated the levels of understanding by visitors self-administering a Likert scale. Most results generated by self-assessment are significantly different from the results as scored by the researcher (see Methods section in this chapter). Hence, in order to design a criterion for a standard score for the respondents who came from different ethnic groups and various cultural backgrounds, this should be based on the standard assessment by the author rather than their self-assessed scores.

For the results relating to conceptual understanding, they showed that three respondents who had different study levels and varying cultural backgrounds (such as ethnicity, nationalities, and first languages) had their conceptual understanding unchanged. They had belief in their religion which took precedence over the scientific concept in the ‘Big Bang’ exhibit. On the other hand, the two main cultural issues which were apparent on the ‘Big Bang’ exhibit - such as the language issues in scientific words and conceptual understanding - were not changed by the visitors’ learning and understanding gained from using the exhibit. They were more strongly influenced by their religion. Although, this case study did not document the religions involved, the respondents referred significantly to their religious backgrounds by making reference to their ‘God’. Currently, the international and local visitors use the same language - English - to read the graphic panels of the three interactive science exhibits. These visitors may understand the scientific languages by virtue of their educational backgrounds, and scientific television documentaries based on their cultural issues relating to their conceptual
understanding. However, it might show a small number of people in some ethnic groups who may not change their conceptual understanding, dependent on particular religious backgrounds. Other cultural issues may also have some influence on the questionnaire in relation to the language issues and conceptual understanding such as emotional values.

The meaning of ‘direct understanding’ in the new classification of ISTEs proposed in this thesis (Chapters 4 and 5) is not defined, but visitors might be expected to get a higher score than for ‘complex understanding’. However, this is not always true because of cultural differences.

Other cultural issues were apparent in the completed questionnaire such as visual cultures and emotional values. This demonstrated that the questionnaire in this case study, designed using ‘open-ended’ questions, had succeeded in making respondents use their critical thinking to generate an answer. These additional cultural issues might not appear in answers provided in the multiple-choice questions, and so the open ended questions were another possible means of generating material on cultural issues.

Levels of understanding of the respondents in language issues and conceptual understanding were brought to bear when using the paper-based questionnaire. This understanding could only be established in the brief period of time when they were in the museum and involved in the case study. Following their visit, these respondents could choose to continue their learning if they were curious about the questions and answers in the questionnaire. They might try to search, read and watch using the internet, library resources, and any scientific documentary on the television or video online to find out more information about the science that they had encountered in the museum. Other dimensions of cultural issues – e.g. physical skills, technologies issues, language issues, visual cultures, social issues, emotional values, prior age, and disabled people – can be investigated by using the video recordings in this research to examine how home and oversea visitors interact with the exhibits. However, gender issues relating to the three ISTEs – ‘Gravity well’, ‘Big bang’, and ‘Getting the
picture’ - could not be identified from the clip videos that were recorded. It is possible that if more time was spent, gender issues could be identified.

Furthermore, the paper-based questionnaire had limited facility for investigating the respondents’ interactions with the exhibits. The video recording and observations of the respondents’ interactions did provide material to explain why the respondents could not understand and learn from the interactive science exhibits. For example, one British respondent replied on the questionnaire that “It didn't work, sorry” (no.5, female, 20-29 years old, working, British, England). This woman and another person participated together on the ‘Big Bang’ exhibit. The video records and observations revealed that both of them did not spin their discs at a high enough speed to launch the particles out. It also meant that they could not see any virtual scattering of particles on the white table of the exhibit. The statement “…It didn’t work…” was correct, but the implication that this was caused by some deficiency in the exhibit was wrong. This lack of speed was the reason why these respondents failed to interact with the exhibits and produced these results. These two respondents thought that the reason they could not get the intended demonstration from the ‘Big Bang’ exhibit was that it was broken. Although they tried to manipulate the exhibit to make it work, no visitors around the ‘Big Bang’ exhibit made any suggestions to help them.

In addition, respondents needed to apply other cultural knowledge to support their interactions so that appropriate help would enable them to successfully access the exhibits. For example, the respondents did not understand how to use their hand movements to manipulate the ‘Getting the picture’ exhibit. They looked at the hand images and read the information on the instruction board relating to the exhibits. On the other hand, the respondents could have used visual information to help them make appropriate hand movements.

6.8 Critique of study

The ‘Gravity Well’ exhibit was the only exhibit where a simple interaction with complex understanding was found. Further information about the underlying concepts was available from a few resources from museums on the internet – e.g. “This exhibit combines a visual demonstration of Kepler’s laws of...
planetary motion with the option to raise money by using the Gravity Well as a donation-attracting device” (Exs, 2013, para.1), “However, friction slows down the ball, until the ball is attracted towards the central hole by gravity.” (Questacon, 2013), para.4), and “Send pennies spinning around the center hole to get an idea of how gravity and momentum work to keep the planets orbiting around the sun” (Montshire Museum of Science, 2013, para.1). This can be a useful reference for identifying the levels of conceptual understanding of the visitors. However the two exhibits - ‘Big Bang’ and ‘Getting the picture’ - only have the information on their graphic panels and further scientific concepts could not be found from the website of the National Space Centre (2013). It is possible that these two exhibits are unique to the National Space Centre. However, the author can create the Rubric scale by comparing the answers of several respondents who can give an accurate explanation of these two exhibits – the ‘Big Bang’ and ‘Getting the picture’ - and other respondents who cannot. Then the scores can be categorised into the different levels of understanding.

The recording of videos and observation of this case study 3 were not used to determine the ‘time of attracting power’ and ‘holding power’. Rather they were observed in terms of patterns of behavior, social, and cultural contexts of visitors interacting with ISTEs. This is because the time of observation by the author was limited because videos of all the three ISTEs used by several respondents cannot be recorded at the same time.

The numbers of some ethical groups of the sample were too small after they were categorised at the educational levels. For example, the ethnic group A in the secondary level has only six respondents and the ethnic group C in the further education level has only five respondents. The sample sizes are too small to support any statically significant results.

The results of conceptual understanding and language issues in case study 3 were assessed by one researcher (the author) who used the Rubric scale to increase the intra-coder reliability by having a standard set of criteria. This may differ from the perspective of Hruschka et al. (2004) who cited the dangers of coding bias and random mistakes with a single interpreter.
However, the author had limited time to find other coders or experts to interpret the same texts. This interpreting of the code for this case study should ideally have used more than two coders, which have reduced bias error of inter-coder reliability as Hayes and Krippendorff’s (2007) state.

The time scale of the experimental research in relation to national holidays is very important. If the survey did not collect data before Easter holidays 2013 (Sat 30 March 2013 – Sun 14 April 2013), this will affect the sample of respondents. They may not be drawn from the local visitors (family and school groups) as they may be on holiday.

The respondents within this study always discussed and spoke with each other – e.g. family groups, couples or friends. This case study did not see that these groups separated into individuals when using the ISTEs. For example, children preferred to show their parents when they interacted with these three ISTEs. Hence, this social behavior of the respondents might help them to improve their level of understanding for both language issues related to scientific words and the conceptual understanding of how the exhibit works.

6.9 Summary of chapter 6

6.9.1 This case study has investigated how the characteristics of interactive science and technology exhibits take account of cultural differences which affect learning. Case study 2 (reported in Chapter 5) investigated the relationship of interactive designs to the two most significant cultural factors – ‘conceptual understanding’ and ‘language issues’. The conclusions are based on the opinions of experts around the world, and the experimental results that this research has generated. In case study 1 in Chapter 4, the two main characteristics of ISTEs - ‘interactions’ and ‘understanding’ - are classified in 4 groups in the new classification proposed for ISTEs. What has to be determined is how these two main characteristics of ISTEs and the two dimensions of the cultural issues affect visitors’ learning. This is done using the pre-test and post-test of the visitors’ knowledge before and after interaction with the ISTEs.
In terms of cultural differences in this study, the visitors of the target museum, the National Space Centre, come from the UK and overseas, divided in five main cultural regions. This research is using the ethnic grouping of the National Archives (2013) - A: White, B: Mixed, C: Asian or Asian British, D: Black or Black British, and E: Chinese or other ethnic group.

The conceptual understanding was gained through visitors’ knowledge acquired from the use of the ISTEs in physical science subjects e.g. the ‘Gravity Well’, ‘Getting the picture’, and ‘Big Bang’ exhibits. The language issues were explored through visitors’ knowledge required by the use of the three scientific words in physical science subjects i.e. ‘gravity’, ‘focus’, and ‘particle’.

This case study shows that the educational levels and ethnic groups of visitors significantly affect learning in the case of home and overseas visitors. Overseas visitors who use English as their second language have significantly lower scores for their understanding of the three scientific words and lower scores for their conceptual understanding of the three ISTEs compared to the British people who are local visitors.

Language issues and conceptual understanding are the main factors used in the investigation of the visitors’ learning through ISTEs. In addition, there are eight other dimensions of cultural issues relating to ISTEs affecting visitors’ learning. These effects - e.g. physical skills, technologies issues, language issues, visual cultures, social issues, emotional values, prior age, and disabled people - were examined by analysing video clips. However, use of these three ISTEs did not provide video material for the examination of some issues, e.g. conceptual understanding and gender issues relating to visitors’ interaction. The ‘Gravity Well’, ‘Getting the picture’, and ‘Big Bang’ exhibits were appropriate for both genders.
Chapter 7
Discussions

7.1 Introduction
This chapter provides the discussion of this thesis. It discusses the new classification of ISTEs, overall new classification at the science museums and the existent 10 dimensions of the cultural issues. The reasons for replacing the terms ‘cultural factors’ with ‘cultural issues’ in the title of this thesis will be stated. Particularly, cultural factors relating to ISTEs studied in the three case studies were again explored in order to re-examine other important factors which may relate to cultural differences and may affect learning by means of ISTEs.

<table>
<thead>
<tr>
<th>Research questions of the enquiry:</th>
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<tbody>
<tr>
<td>RQ 1 What is culture, and what is the meaning of cultural differences?</td>
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<tr>
<td>RQ 2 What is meant by interaction, and what is an interactive science and technology exhibit?</td>
</tr>
<tr>
<td>RQ 3 Why is the classification of interactive science and technology exhibits so important for today and the future; and what classifications are there?</td>
</tr>
<tr>
<td>RQ 4 How to define the relation between the cultural differences and interactive science and technology exhibits, and what categories of cultural differences are there?</td>
</tr>
<tr>
<td>RQ 5 What interest have the experts of the museums of science in culture influencing the use of interactive science and technology exhibits; and which cultural issues do they believe are the most important?</td>
</tr>
<tr>
<td>RQ 6 How do the characteristics of the interactive science and technology exhibit take account of cultural differences which affect learning?</td>
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<tr>
<td>RQ 7 What are other factors which significantly contribute to cultural differences in learning to use and using interactive science and technology exhibits? For example, age, gender, and educational levels. Why are these factors related?</td>
</tr>
<tr>
<td>RQ 8 How can interactive science and technology exhibits be developed to capitalise more successfully on cultural differences?</td>
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</tbody>
</table>

Table 7.1: Research questions in chapter 7
7.2 Background

As in the previous three chapters - chapters 4 to 6 - the three case studies have been used to narrow down the investigation of the research questions. The mixture of methods can help to explore several findings in these case studies - e.g. the new classification of ISTEs, and the cultural issues relating to ISTEs – which are described in 10 dimensions. The most important cultural issues respectively are language issues and conceptual understanding. These findings from the three case studies relate to the interaction of visitors using ISTEs in various cultures, and this will be discussed in this chapter.

7.3 Aims and objectives

The overall aims of this discussion chapter are to:

- Understand other factors – e.g. age, gender, and educational levels - which may significantly contribute (with cultural differences) to affect learning to use and use of interactive science and technology exhibits.

The particular study objectives were to discuss:

- How the findings in the three case studies may help to develop a contextual model of the cultural factors, which may provide answers to the research questions. For instance, other factors – e.g. age, gender, and educational levels – may interact with the cultural factors.

- The flowchart of the new classification of ISTEs and how the flowchart may be represented to facilitate the categorisation of ISTEs in their proper groups/classes.

- The reason for the replacement of the term ‘cultural issues’ by the term ‘cultural factors’ in the title of this thesis.

- The limitations of all of the studies reported in this thesis.
7.4 Generating the findings from the triangulation model of the three case studies

The mixed methods of the three case studies shall be considered by a discussion of all findings and their representation by a 3D-visualised model showing triangulation. The author develops this triangulation model into three layers in the following figure.

![Figure 7.1: Flowchart of the triangulation model of the three case studies](image)
The core of the three case studies is the cultural issues relating to interaction design. This is investigated using several methods – e.g. cluster analysis, interviews, questionnaire, and recording video observation. The purpose is to identify the relationship of the research findings to the real world which can be explained as follows.

- The first layer shows case study 1 that began to explore the dimensions of cultural issues relating to ISTEs - e.g. physical skills, technologies issues, social issues, language issues, visual cultures, and conceptual understandings – in the work on science education initially done by Awsakulsutthi (2009a; 2009b; 2009c). The classification based on the new classification of ISTEs in the four groups. The two main results in case study 1 were the paper-based questionnaire responded to by the 16 PGCE students of Loughborough Design School, and interviews with the two experts (one from the Snibston Discovery Museum, UK, and another expert from the NSM, Thailand). These experts gave their recommendations for finding and defining further dimensions of cultural issues; this starts in case study 2.

- The second layer of this figure shows case study 2 using network analysis to identify more dimensions of cultural issues relating to ISTEs. Four further dimensions were found – i.e. emotional values, age issues, disability, and gender issues. Then the online survey of the 10 dimensions of cultural issues relating to ISTEs was distributed to many experts at science museums/institutions around the world, which have ISTEs. The results of case study 2 narrowed down the two most important cultural issues by a quantitative method which was voted on by the 121 museum experts – language issues and conceptual understanding. Additionally, a linkage was made to other results. To achieve this, a qualitative method was used with the validations at 10 museums of science in the UK which were observed and the relationships were identified by the author.
• The third layer shows the research methods used – paper-based questionnaire, Rubric scales, and video recording observations. These were used to evaluate 121 respondents who were the visitors of the target museum, Snibston Discovery Museum in the UK. Finally, the bottom of this model of the research results from these three case studies show the 10 dimensions of cultural issues related to each other, and significantly their importance for interaction design. There were two main cultural issues – language issues and conceptual understanding – which were of the greatest importance.

7.5 Flowchart categorising the new classification of interactive science and technology exhibits (ISTEs)

This section will describe a flowchart which shows a process of categorising ISTEs into one of four groups of the new classification. This diagram was developed from the new classification of ISTEs in case study 1 which identified the 56 ISTEs at the NSM, Thailand and connected with the results in Case study 2 (See section 5.52 - Phase 2: Validity of the 10 dimensions of cultural issues relating to ISTEs at the museums of science). For example, case study 1 - the 56 ISTEs of the NSM in Thailand - did not have any exhibit emitting smells, but other ISTEs in case study 2 emitted ‘smells’ - e.g. visitors can smell the objects in ‘What is this material?’ exhibit (See Figure 5.74) - at the Science Museum in London.

Additionally, some patterns of visitors’ interaction and behaviours in case study 3 are clearly repeated and show the character of ‘multiple-interactions(s)’ of ISTEs. This was found in particular cultural issues such as physical skills (e.g. the ‘Big Bang’ exhibit is manipulated by visitors rotating a handle with the other hand pressing a button). Social issues are involved with ISTEs which used by more than one visitor. This compares with several classifications of ‘interactive science exhibits’ of other researchers in the literature review - e.g. Boisvert and Slez (1995), Ghose (2000), Gilbert and Stocklmayer (2001), Sandifer (2003) and Afonso and Gilbert (2007). These researchers did not show the classifications process in their publications in terms of a flowchart.
Figure 7.2: Flowchart for categorising the new classification of ISTEIs

[Figure developed by the author, Sumath Awsakulsutthi]
The diagram in Figure 7.2 may offer a more advantageous process of classification than these and other previous researchers to help any exhibit team developer – e.g. science educators, curators, exhibit designers – to categorise the ISTEs in their museums (See the reason for why the new classification are needed in section 2.14.5 (Summary in Chapter 2). It may also lead to more effective design for increase interaction and learning.

7.6 Changing the title ‘cultural issues’ to ‘cultural factors’ relating to ISTEs

In the background information in the ‘introduction’ chapter, the author described the crucial hypothesis that the interaction between visitors and interactive science and technology exhibits (ISTEs) may be influenced by their cultural differences. For example, this was shown for the ‘real image’ exhibit at the NSM in Thailand and ‘3D ‘Shake Hands 3-d reflections’ exhibit of the MOSI in the UK. Hence, it is possible that other ISTEs at the museums or institutions in other cultures of many countries around the world may have the same phenomena – their visitors’ interactions are affected by cultural differences between the visitors.

The term ‘cultural issues’ in this research means that a potential barrier to interactions may affect international visitors (who may not live in the country where the museum is located) electing to use ISTEs. In addition, if the cultural issues are not taken into account during design, it will mean that the interaction with the exhibit will be impaired. Examples are ISTEs where visitors misunderstand what they need to do to manipulate the various parts of an exhibit, or persons who have not seen or are unfamiliar with some functions of interactive science exhibits in their cultural backgrounds e.g. speaking on a focal area of a parabolic dish exhibit at the NSM in Thailand (See Figure 5.71: ‘Speaking dishes’ exhibit). Moreover, local visitors who have varying cultural backgrounds in the same country may also be affected. Cultural issues may cause different reactions from local visitors using the same interactive exhibit. For example in case study 2 in Chapter 5, several ISTEs at the 10 Science museums have technologies comprised of modern devices, especially electronic sensors and touch screen monitors. This
equipment may be used to access the system, and this equipment is more familiar to many young and adult visitors who live in large cities than the visitors from the small towns.

The title of this thesis is ‘A study of the importance of cultural factors in the user interaction with, and the design of, interactive science and technology exhibits in museums’. The previous chapters have always used the term ‘cultural issues’ - being a slightly negative term. After the three case studies have been analysed to generate the results, the author has chosen ‘cultural issues’ to be replaced by the term ‘cultural factors’ which is more neutral. The term ‘cultural factors’ significantly affects the design and development of interactive science and interactive exhibits (ISTEs) which influences visitors’ learning, understanding and interactions. Also the word ‘factor’ means “one of several things that cause or influence something” (Oxford Advanced Learner’s Dictionary of Current English, 2000, p.450).

Also this section will discuss the research question, RQ 7: What are the other factors which significantly contribute to cultural differences in learning to use and using interactive science and technology exhibits? For example, age, gender, and educational levels. Why are these factors related?

The results of case studies 1, 2, and 3 will be brought together into a coherent body of knowledge to answer the above question. The conceptual understanding of scientific perception and language issues with scientific words may originate from several mixed sources before they interact with ISTEs. These include previous knowledge, cognition, and experience of visitor(s) – e.g. fairy tales, movies, books, (found in case study 1 from the literature review), science documentaries on the television or radio and religion (the respondents in case study 3 who believe in God). On the other hand, it means that education levels are important to providing information, and generating cognition and experience which embed into local visitors or international visitors. However, local and international visitors may have different background information originating from the 10 different cultural factors. Age and gender are part of cultural factors – e.g. age issues and gender-related issues – and were found in case studies 1 and 2. Hence, any
individual visitor has several cultural factors shaping their own personality - e.g. age, gender, and educational levels (educational levels impact on conceptual understanding) which influences visitors’ ability to use ISTE. For example, a teenager who achieves significantly higher educational levels may get a higher score for their understanding of ISTE rather than the older people in case study 3.

The author classifies these 10 dimensions of cultural factors into the three learning contexts of science education which were reported in the literature review by several researchers such as Bamber and Tal (2007), Braund and Reiss (2004), Dierking and Falk (1992), Falk and Dierking’s (2000). The 10 dimensions of the cultural factors relating to ISTE in the three contexts are shown in the following diagram.

![Diagram of cultural factors affecting the design of user interaction(s) and visitor understanding of ISTE at museums of science, through out-of-school contexts](Figure 7.3)

**Figure 7.3:** A contextual model of cultural factors affecting the design of user interaction(s) and visitor understanding of ISTE at museums of science, through out-of-school contexts

[Figure developed by the author]
A contextual model of cultural factors has been developed from case study 2 which was based on the validation of the new classification of ISTEs relating to the 10 dimensions of the cultural factors at the 10 museums. For example, significant multiple interactions with direct- and complex understanding were found between the personal context and the sociocultural context. Outdoor ISTEs may involve the cultural factor ‘age issues’ in a physical context which offers more space for children where they can run and enjoy good weather outside the museum buildings. This point about the ‘age issues’ of young visitors is similar to Schneider and Cheslock’s (2003) viewpoint (reported in the literature review) that children enjoy interacting with ISTEs more than adults. Further, this model also illustrates the relationship between cultural factors relating to ISTEs through their person context and sociocultural context e.g. emotional values and social issues. This viewpoint supports Piscitelli et al.’s (2003) perspective in the literature review that children enjoy learning with an interesting object or one which connects with their prior experience.

In the following figure, the contextual model of cultural factors relating to ISTEs –the middle model can project into the three contexts (the personal context, the sociocultural context, and the physical context) to generate the ‘contextual model of learning’. For example, the ‘contextual model of learning to understand visitors learning from a science centre exhibitions’ of Falk and Storksdieck (2005) is on the left-hand side. Another example, the ‘contextual model of learning in information, out-of-school contexts’ of Braund and Reiss (2004) is on the right-hand side. Both of these models were found in the literature review.
Figure 7.4: Projecting the contextual model of cultural factors relating to ISTEs in the middle into the two contextual models of learning - Falk and Storksdieck (2005) on the left and Braund and Reiss (2004) on the right

[Figure developed by the author, Sumath Awsakulsutthi – with using the information from Falk and Storksdieck (2005, p.747) and the right image retrieved from Braund and Reiss (2004, p.115)]
In addition, this contextual model of cultural factors concerns the development of ISTEs relating to visitors’ interaction instead of the models of learning addressed in the contextual models of learning of Falk and Storksdieck (2005) and Braund and Reiss (2004). Additionally, this model mapping helps to organise ISTEs to produce terms appropriate for their use e.g. complex and direct understanding may be simplified, reduced or adjusted and put within a discovery process. This discovery process is instead of a ‘cognitive perspective’ as in school science teaching of Millar’s (2004) perspective for applying ISTEs for school visiting and supporting further informal learning system e.g. motivation, enjoyment, and relaxation, which is other researchers’ viewpoints (Brody et al., 2002; Falk, 2005; Heimlich et al., 2004).

7.7 The importance of cultural factors to defining the desirable characteristics of interactive science and technology exhibits (ISTEs)

“The modern thinking on IQ tests is that the most reliable are culture free, where no prior knowledge or skill with words is necessary. A culture-free test breaks down all language barriers. Such tests are truly international and can be applied to all people, irrespective of creed and culture” (Russell and Carter, 1989, p.1). It is therefore important that ISTEs at museums of science around the world are similar to the IQ test, i.e. ‘culture free’.

The author poses a basic question relating to the research title of this thesis ‘Why is this study of cultural factors relating to ISTEs important to user interaction with, and the design of ISTEs?’ The following figure forms the basis from which an answer may be derived from this research.
The four main answers to this research question are shown as:

- First, this study of the cultural factors is directly important to ISTEs because it bridges the gap between the two main components of ISTEs - scientific knowledge and interaction design. On the other hand, the two terms originating from the two characteristics of ISTEs - interaction and understanding of scientific knowledge – are an integral part of the new classification.

- Second, the four main groups of staff at the science museums involved with ISTEs will benefit from the output of the research concerning the cultural factors as follows.
  - [1] The back-end staff who prepare scientific knowledge information – e.g. science educators, curators, and museum...
researchers. The two major cultural factors which have emerged from the research are conceptual understanding and language issues. This information is most relevant to these staff who provide support to the visitors.

- [2] The back-end staff who develop an interaction design and are involved with ISTEs - e.g. exhibit designers, exhibitors, and exhibit developers – should understand about cultural factors relating interaction to the design of ISTEs.

- [3] The back-end staff who are directors or managers of science museums may decide to organise their ISTEs consistent with the layout of the real world, and relating to their local and international visitors who have different cultural backgrounds. This research will provide valuable additional information to assist their design and planning of museum layouts.

- [4] The front-end staff who are official staff and volunteers who directly meet visitors face-to-face. If the information about cultural factors was given to these staff they may be able to modify their treatment of the visitors. This situation may assist them in their explanations to aid visitors in understanding how to interact with ISTEs. On the other hand, the museum may have limited budgets curbing volunteers’ numbers on each exhibition gallery. They may modify their volunteer policy using this information.

- Third, visitors who are local and international visitors visiting science museums as individuals, tourists, family and school groups – who may spend less time learning ISTEs through their interactions because of cultural factors - may be better supported by exhibit developers. This may also support disabled people learning to use ISTEs in various cultures.
Fourth, the cultural factors affecting the organisations (e.g. science museums, science centres, private companies, and other institutes) which have developed ISTEs will obtain benefit for the design of exhibits. They can use cultural factors as an optional feature in the further lifelong education for their local and international visitors. Every country may have mixed cultures, e.g. English, Northern Irish, Scottish, and Welsh people in the UK have their own cultures such as customs, architecture, language and gestures. These mixed cultures in the UK also influence peoples’ lifestyles regarding visiting museums which is McDermott's (2004, p.30) viewpoint that “In the 21st century the UK's design strength is exploring this cultural diversity in its sense of city and national identity. These days what is exhibited and promoted as British design in museums, UK Government promotional exhibitions, magazines and books is - in terms of nationality - incredibly diverse.” At present, science museums in developing countries may import or duplicate the idea of ISTEs from developed countries without consideration of cultural factors. In the future, science museums in developed countries should emphasize design with regard to cultural factors when they export ISTEs to developing countries.

7.8 Developing design guidelines for ISTEs related to cultural factors

As the results of the three case studies demonstrated in the previous chapters, new knowledge about the dimensions of cultural influence relating to ISTEs was discovered. This should be distributed as a package of information to support museums of science around the world in the development of their ISTEs, taking into account the cultural factors identified.

The main reason for developing good exhibits for local and international visitors who have different cultural backgrounds is that ISTEs can be installed in any worldwide science museum which are accessible to all visitors. The design guidelines are a means of providing structured relevant knowledge to achieve this end.
As well as the cultural factors in this thesis, the exhibit designers and science educators who are the main developers in the design team for ISTEs in any science museum may need to access other resources with other design information. For example, Krafft (2006, p. 103) pointed out that “What Makes a Good Exhibit? The Sciencenter developed a set of guidelines to keep in mind when planning and building exhibits - this makes interesting exhibits, with good underlying science or maths content, where visitors can manipulate and affect the outcomes, and where they can be surprised. Further, Krafft (2006) summarised ‘Sciencenter Exhibit Design Guidelines’ in four main areas as follows:

- Concept (relating to everyday life and experiences, enabling the encouragement of interaction groups of people, appealing to several ages for enjoyment).

- Educational aspects (science content, open-endedness, interactiveness e.g. smell, touch, manipulation).

- Design and construction (build ability, repair ability, maintainability, survivability, affordability of estimation and comparison, testability, networking with other exhibits).

- Other considerations - safety (e.g. not loose parts, or choking hazards), signage and labels not too long for reading and good position for seeing, disabled accessibility (e.g. by wheelchair), the user reach, and enhancing the visitor experience.

In addition, Kennedy (1994) who is an exhibit designer wrote a book ‘User Friendly: Hands-On Exhibits That Work’ which discusses human factors in several contexts e.g. human measurement (one size fit all visitors, wheelchairs, and waking aids), controls (using labels to tell visitors e.g. push, pull, and turn), maintenance (convenient and not requiring excessive maintenance) and safety (no sharp edges, use of safety glass etc).

The cultural factors relating to ISTEs in this thesis will be useful for developing ISTEs in various cultures, given the increase in globalisation. The
cultural factors are incorporated in the 10 dimensions. Further, any staff at a science museum should incorporate these cultural factors with other important resources for design of exhibits - e.g. ‘User Friendly: Hands-On Exhibits That Work’ (Kennedy, 1994), ‘Making Effective Exhibits for Rewarding Visitor Experiences’ (Krafft, 2006) and ‘Universal Design in North American Museums with Hands-on Science Exhibits: A Survey’ (Tokar, 2004)

Hence, the design guidelines are presented in the next chapter. They provide a checklist in terms of the 10 dimensions of cultural factors relating to ISTEs for consideration by the design teams. These are in a similar format to a list of researchers in the literature reviews: Bruman (1984), Hipschman (1980; 1987), Lin (2009), etc.

7.9 Overall limitation of this research study

This thesis has research limitations due to several causes. There was a limitation of selected groups of the respondents in the online questionnaire, e.g. only a few exhibit designers, and the volunteer staff. For the paper-based survey there were limited numbers of international visitors in some ethnic groups. The main limitations will be explained below.

The viewpoints of the author are limited in terms of a background which is not as a designer, and was someone born in Thailand with Asian cultural influences. The author has been living in the UK for only five years including the year when he studied a Masters programme of Science Education at the University of Leeds. The author may identify some cultural factor terms which have given him a different perspective from many Western educators. For example, the author believes that age issues are part of his Asian culture. Most people in any society should support age issues – young and old people - using and learning ISTEs in the same the way as teenagers and younger adults. The older and younger people always need special support in public activities and in the education system. Several Western experts believe that taking into account age issues is not part of ‘cultural factors’ and they gave several reasons:

- No, ‘I think it is common for all people to sit in a chair, on a rock…. So it is the same thing in all cultures, and different approaches due to age
difference (that you mention) will be equally present in any country’ (N.D., Coordinator of Science Exhibitions, Belgrade’s Science festival and Science Park Belgrade, Serbia).

- No, ‘Certain things are designed for certain ages - this is universal between all cultures. Places that are experienced with international audiences such as Disney have found ways to prompt visitors as to the safe use of the exhibits’ (Anonymous, Exhibitor, Berkshire museum, USA).

- No, ‘I think there are universal concerns, as older people tend not to interact with exhibits as much as younger people do, but I do not think the age issue is a cultural issue’ (D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

Most science museums in this research – e.g. the Science Museum in London, the National Space Centre, the Snibston Discovery Centre and the Enginuity of Ironbridge Gorge Museum - are located in the UK. Only one museum is in Thailand, the NSM. The examples of these existing ISTE}s may significantly differ in terms of interaction design and information provision on the graphic displays from other zones and cultures in the world – e.g. Northern America, Middle East, and Oceania. The exhibit staff teams at the science museum in many parts of the world may design their ISTE}s in ways appropriate for their local visitors, rather than international visitors. The author has not been able to visit science museums in other countries (apart from Thailand), where their cultural factors may vary greatly. The research would be greatly enhanced and its validity and applicability would be increased with inputs from other part of the world, not covered by this research.

An online survey was the main method for obtaining information from 121 experts. The author believes that if an interview method was used, this would enable a more detailed, and informed exploration of the many experts’ considerable resource of knowledge and experience.
7.10 Summary

The findings of three case studies are developed with multi-methods and triangulation. This can be used to generate answers to the research questions relating to factors such as age, gender, and educational levels, which are relevant to the cultural issues.

The flowchart for the new classification of ISTEs is described and discussed. It has been developed to categorise ISTEs into one of four main groups. This categorisation can be used to understand the characteristics of each ISTE and design effective exhibits.

The reason for the replacement of the term ‘cultural issues’ by the term ‘cultural factors’, as used in the title of this thesis, has been explained in this chapter.

The main limitations of the research in this thesis are: (1) the cultural viewpoints of the author who is Asian, and has been living in the UK for only 5 years, may differ from other experts in other countries; (2) most examples of ISTEs were located in the UK rather than a range of cultures; (3) not using a more detailed interview method with experts in museums in a range of countries because of the constraints of time and budget for this research.
Chapter 8
Conclusions and Design guidelines

8.1 Introduction
This chapter reports the conclusions generated relating to the cultural issues that affect the design and use of interactive science and technology exhibits (ISTEs) in science museums worldwide. It summarises the main findings from the research.

The recommendations for future work are indicated, emphasising the how understanding essential cultural factors should influence development of the infrastructure of ISTE.

Design guidelines have been developed from the studies and the information from the museum experts from around the world. It is intended for directors, curators, science educators, exhibit designers, and other museum staff who are involved with the creativity of design, planning, building, and use of ISTE - which are major target groups for the output from this thesis.

<table>
<thead>
<tr>
<th>Research questions of the enquiry:</th>
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<tbody>
<tr>
<td>RQ 1 What is culture, and what is the meaning of cultural differences?</td>
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<tr>
<td>RQ 2 What is meant by interaction, and what is an interactive science and technology exhibit?</td>
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<tr>
<td>RQ 3 Why is the classification of interactive science and technology exhibits so important for today and the future; and what classifications are there?</td>
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<tr>
<td>RQ 4 How to define the relation between the cultural differences and interactive science and technology exhibits, and what categories of cultural differences are there?</td>
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<tr>
<td>RQ 5 What interest have the experts of the museums of science in culture influencing the use of interactive science and technology exhibits; and which cultural issues do they believe are the most important?</td>
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<tr>
<td>RQ 6 How do the characteristics of the interactive science and technology exhibit take account of cultural differences which affect learning?</td>
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<tr>
<td>RQ 7 What are other factors which significantly contribute to cultural differences in learning to use and using interactive science and technology exhibits? For example, age, gender, and educational levels. Why are these factors related?</td>
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<tr>
<td>RQ 8 How can interactive science and technology exhibits be developed to capitalise more successfully on cultural differences?</td>
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Table 8.1: Research questions in chapter 8
8.2 Main findings

The first finding was that the previous classifications of interactive science exhibits from several researchers - e.g. Ghose’s (2000), Gilbert and Stocklmayer’s (2001) and Sandifer’s (2003) – do not clearly identify any interactive science and technology exhibits into specific groups (See Appendix 4: Overlapped categories in the existing classifications). The first evidence of this finding came from an evaluation of these classifications in case study 1 through the 56 interactive science exhibits at the NSM, Thailand. Further evidence came from validation of the new classification of ISTEs at the science museums in case study 2. The new classification is useful to classify the exhibits into particular groups and explains specifically a definition of each group better than the previous classifications.

The second finding was that cultural issues were strongly influencing the use of ISTEs. The first evidence came from validation of the new classification of ISTEs at the science museums in case study 2. This study also showed that the cultural issues affect the optimum interaction design and the scientific knowledge required, to develop ISTEs in museums. Further evidence came from the online survey results in case study 2 of 121 experts worldwide (including directors, educators, designers and staff) who believe that these 10 dimensions of cultural factors are important factors affecting the use of ISTEs by visitors.

The third finding was that visitors learning was influenced by educational background and ethnic grouping i.e. – White; Mixed; Asian or Asian British; Black or Black British; and Chinese or other ethnic group. The first evidence came from the results of the online survey in case study 2 that the two most important of cultural issues relating to ISTEs assessed by the 121 experts were ‘conceptual understanding’ and ‘language issues’. Additional evidence came from the results in case study 3. It was shown that the effect of education is different for home and overseas visitors when using ISTEs, in relation to its impact on learning.
8.3 Contributions to knowledge

This thesis produced a number of contributions to knowledge relating to interactive science and technology exhibits. It provides an answer to the last research question ‘How can interactive science and technology exhibits be developed to capitalise more successfully on cultural differences?’ and the findings are described in this chapter. This research will be reported in three main forms as follows.

First, there is a proposal for a new classification of interactive science and technology exhibits, comprising four main groups based upon the user’s perception, cognition, and the nature of user interaction(s). These groups are: simple interaction with direct understanding; simple interaction with complex understanding; multiple interactions with direct understanding, and multiple interactions with complex understanding. This knowledge contained in the new classification will be useful for any science museum wanting to organise their ISTEs based on the type of interaction they want to provide with their exhibits.

Second, the 10 dimensions of the cultural factors, which are shown in the literature review, are intended to address the gap between science education and interaction design. They can be useful for any science museum in the world to develop and design their ISTEs. This knowledge will help the science educators and designers understand the importance of cultural factors and their impact on the design of ISTEs. This will help museums develop suitable ISTEs bearing in mind the cultural factors, so as to produce ISTEs appropriate for their local and international visitors.

Third, the design guides for developing interactive science and technology exhibits (ISTEs) are developed using the 10 dimensions of the culture factors relating to ISTEs. These are as follows:

1. Physical skills
2. Technology issues
3. Language issues
4. Visual cultures
5. Conceptual understanding
6. Social issues
7. Emotional values
8. Age issues
9. Gender issues
10. Disabled people
The design guidelines were developed in part from sources in the literature review and in part from the results of the three main studies. The guidelines are intended to support a range of experts – e.g. directors, science educators, and exhibit designers - in any science museum in the world and are designed to capitalise on the new found knowledge about cultural differences. The guidelines provide information relating to the consideration of cultural factors in the design of the exhibit. This consideration will be in a form which identifies the design decisions which should be influenced by this information, relating to the nature and acceptability of the interaction. This complements the existing knowledge in the design of ISTEs.

8.4 Recommendation for future work

Areas and proposals for further research have been generated during the course of this PhD. This is outlined in the following four paragraphs.

- **Fundamental studies:**
  This research has not been able to exhaustively and comprehensibly consider cultural factors worldwide. For example, of the science museums in Asian countries – e.g. Japan and Korea – no institutions from these countries responded to the online survey in case study 2. This diminished the research because it had a lack of information on the cultural factors in these two countries having major Asian cultural backgrounds. To address this, a revised online survey could be sent to science museums in countries which did not reply to the first online survey. The new work will seek to generate further research information and the second attempt will adopt a different approach to getting a good response. The different approach will be shaped by insights into the reasons for the first online survey’s failure to get responses from some countries.

- **Specific studies:**
  At present, the literature review identified gender issues which were specific to the male or female gender, rather than e.g. transgender, neither or both. Hence, the study should support the interaction design
of ISTEs to connect with all groups taking into account their physical skills, social issues, and emotional values. However, these genders should be of concern to research ISTEs in term of moral principles and importance of educational purpose rather than focus on the genders. This area may be of particular interest to Thailand where the culture features a small minority of people in the category of transgender.

- **Developing the open-source software relating to cultural factors and ISTEs for worldwide:**

A range of experts – e.g. directors, educators, curators, and exhibit designers, and other researchers – may be interested in accessing the design guidelines relating cultural factors to the design and use of ISTEs. If the design guidelines could be developed in an intelligible and accessible format such as an open-source software like Wikipedia, this may prove a convenient way to help these experts, as well as research students and young designers. It could help to promote design and analysis of ISTEs in terms of cultural influence. Also this open-source software could be evolutionary with regular updating of the knowledge relating to cultural factors with contributions from other experts who may have experience of ISTEs in their science museums. The further research to develop the guidelines would require careful and appropriate management of the evolving context of the guidelines. So at the highest level of management, there could be a steering committee, composed of at least one representative of each participating country. For example, the cultural factors influencing the design of the ‘real image’ exhibit of the National Science Museum in Thailand and the different cultural practices affecting the ‘Shake Hands 3-D reflections’ exhibit of the Museum of Science and Industry in the UK. This was described in the introductory chapter of this thesis. This information could be installed into the design guidelines database of the open-source software.

The basic operation of the software for analysing cultural factors relating to ISTEs involves two main processes. First, ISTEs will be
classified into their most appropriate group in the new classification. Second, the software will suggest to the users – such as exhibit designers, curators, and science educators – to analyse the ISTEs using the 10 dimensions of the cultural factors. This software may go beyond the design of the individual ISTEs and recommend the layout of groups of ISTEs as in an exhibit gallery. This layout could cater for a progressive increase in the demands made upon visitors. The entry point in the gallery could start the visitor on a simple task, and take them through increasingly complex tasks and types of interaction of various ISTEs in the exhibit hall. This layout exercise would include the use of relevant human data – e.g. access envelope required for wheel chair access and wheel chair bound operation of the ISTEs.

- **Update the design guidelines through the online version:**
  The design guidelines may be distributed in an online version using the open-source software relating to the cultural factors relevant to ISTEs. At present, the design guidelines may be limited to the information provided by the author. Other science museum experts worldwide may be interested to join forces with this open-source software project to develop an updated version for design of ISTEs. Therefore this software can provide an increasingly useful body of information for experts around the world in the future development of ISTEs.

**8.5 Design guidelines for interactive science and technology exhibits (ISTEs) capitalising on cultural factors**

These design guidelines are useful for any person who is interested in developing ISTEs – e.g. exhibit designer, science educator, exhibitor, researcher, and curator. Not only may the guidelines help any science museum with many international visitors, but also there are local visitors who probably have different ethnic backgrounds in the museum. Additionally, the museum directors who may plan to develop and export their exhibits to other museums in worldwide can use the guidelines which may support their visions worldwide.
Any interactive science and technology exhibit (ISTE) can be designed with a checklist of design guidelines as follows, linked to the relevant cultural factors:

<table>
<thead>
<tr>
<th>Cultural factors</th>
<th>Checklists</th>
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<tr>
<td>1. Physical skills:</td>
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<td></td>
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<tr>
<td>Head and face</td>
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There are several kinds of physical skills which involve different parts of the visitor’s body – e.g. head, face, eyes, nose, hands, body, and feet.

The ISTE should be aware about head and face movement for privacy of visitors who are concerned about this in their culture. This is because other visitors may capture this photo by mobile phone or camera. For example, if any ISTE needs visitors to capture their face using a camera and then displays it on screen, it should automatically remove the face on screen after visitors have used it.

The ISTE should be displayed at a correct position if it uses face detection. It is essential to explain this action for visitors who may have never used a capturing camera before. For example, cultural norms may not encourage the visitor to try out the best view of their face whether they pose on the screen of an ISTE in for example the lower or higher position. Their actions, influenced by cultural norm may be interrupted by one group or another.
Eyes

The ISTE should be aware about gestures using eye movements. This is a taboo in some cultures and can impact on personal privacy, if the ISTE enables control of it by eye movements. For example, the ISTE should have a screen to ensure privacy, and can prevent other visitors capturing the image or a video recording of the visitor’s eye movements while they are still using the ISTE.

The ISTE should have a caution label in multiple languages and use visual images for this. This is because of caution in relation to health and safety in some cultures e.g. Western culture. An example would be if the ISTE enables visitors to use their eye movement to operate it over a long time.

Nose

If the ISTE offers visitors experiences via the sense of smell, the ISTE designer should be aware about the impact of certain smells in different cultures. It should be labelled to indicate if this smell is part of a flower or an animal. Smell may cause fear or upset due to their cultural background, or even allergy. For example, Muslims would not choose to smell a pig.

Hands

The ISTE should be designed so that any rotating handle is in the central part of its control panel rather than located on the right or left hand side. Left handed visitors may find it inconvenient to turn a handle on the right hand side of the control panel. Similarly, right
handed visitors may be unfamiliar with using a handle on their left hand side. For example, most young visitors had difficulty operating the handle of a large control wheel which is located on the left hand side of an exhibit. Hence, they could not rotate it fast enough to make ISTE respond.

The ISTE should be labelled with an arrow symbol indicating a direction of rotation on the part of a rotating handle – e.g. clockwise or anti-clockwise. This arrow can prevent the visitors confusing the direction of rotation. The direction of control of the ISTE should be the most natural way which makes visitors comfortable to use the exhibit.

The ISTE should avoid using multiple toggle switches (On/Off) on a control panel. These switches will confuse visitors who are likely to have previously used them in different ways based on on/off, up/down conventions.

Careful design is needed if the ISTE needs complicated operation. This is especially true for children in some cultures. For example, children in the USA may just turn cranks or push the buttons as they wish without spending time reading instructions.

**Body**

The ISTE should clearly provide a proper title and graphic information including an image, if it needs visitors to interact using body movement. This is because several modern ISTEs presently comprise an electronic sensor to detect body visitor body movement. For example, some visitors may not know
about this sensing technology and they may walk away from the ISTE because they may think that it does not work.

Feet

If an ISTE is designed to use feet skills rather than hand skills, then do not suggest that visitors take off their shoes. This is due to the possibility of unpleasant odours from the feet of visitors. In some cultures, e.g. Thai, this impolite.

Any ISTE may be designed to use feet skills in unusual interactions such as stepping on multiple footprints or images. However parents might ask their children to stop using their feet if they do not know that this is how to operate it. An ISTE should provide clear text information with visual images on the graphic panel to make sure visitors can use their feet appropriately.

2. Technologies issues:

The level of technology used in the ISTE should take account of the familiarity of the local population with new technologies. It should provide visual images describing how to operate it. This is because of ISTEs which present its information on digital touch screen. For example, several visitors may have not often use touch digital screen on their experience.

If an ISTE uses a push button for ‘ON/OFF’, a visual display and text information are required to inform the visitor when the system is ‘ON’. The visual display and
text information may prevent visitors operating the
ISTE incorrectly. For example, a label should explain
that you push for ‘ON’, and push again for ‘OFF’.

If an ISTE provides an unusual means of interaction, it
should provide visual/ graphical information to assist
the user in their interaction. This is because any new
technology within an ISTE may cause visitors
confusion when operating it. An example would be
where body movement of visitors (e.g. a gesture) can
control the ISTE.

Every ISTE should be assessed as to whether it needs
to provide an ‘Emergency Stop’ control. Actual
operation should be simple and quick, and this should
be conveniently positioned and protected from
accidental operation. Colour should be used that has
universal cultural meaning. The colour which is most
associated with this function in American and
European culture is ‘RED’, and it should also have a
label associated with the control.

A prototype of the ISTE should be tested with local
and international visitors. This is an effective method
for generating interfaces promoting a high level of
interaction, using user centred design principles. For
example, computer-based interactive ISTEs which
have knobs to control right-and-left and up-and-down
motion will be used by visitors according to cultural
expectations. Testing might show that it is necessary
to include labels on the knobs to show their specific
functions to visitors.
3. Language issues:

The exhibit's title name should be adjusted to take account of any social issues embedded in the title rather than a name based on scientific concepts and language. This is because international visitors may not recognise scientific descriptions due to their culture. The exhibit should provide visual information to provide visitors with guidance on how to interact with the exhibit. For example, the ‘Shake Hands 3-d reflections’ exhibits would be confusing to Thai people. Instead of shaking hands, the normal greeting uses ‘Wai’, which is where one person touches their hands together.

The ISTE should provide an optional unit of measurement for height, area, weight, and time (e.g. week or month or year), and this should be presented on the graphic panel. It is possible to help visitors’ understanding of the operation of the exhibit and its implications for real life if appropriate units are used. For example, this hydrogen car can travel at 87 mph (140 km/h). Some cultures or countries may use different units – e.g. miles and weeks used in the UK, but kilometres (speed) and months (as a unit of time) are used in Thailand.

The optional language could be displayed to visitors. This will be useful for international visitors who can read the ISTE information in their own language. For example, there could be several languages in the form of laminated leaflets suitably located by the ISTE. Alternatively, if there is a suitable multi-media interface on – e.g. computer, mobile phone, tablet, laptop, and
electronic smart watch – other languages could be offered to the visitor using this technology.

The ISTE should provide visitors with additional information relating to key scientific words. It could be based on a glossary panel. They could be centrally located in the museum or mini-glossary panel relating to one or more exhibits or distributed among the exhibit. The main reason for the glossary panel is to help any visitors who may forget the meaning of scientific words or do not know this vocabulary before. For example the word ‘particle’ may appear on the exhibits, ‘Big Bang’ and ‘Atom’. This concept of glossary should be developed further by having a ‘physics glossary’, or panel dealing with other scientific disciplines. The lists whenever they were displayed should be listed in alphabetical order.

In the case of certain museums in particular countries, they should cater for international visitors, possibly in large numbers. Where the local language is little spoken outside that country, consideration should be given to providing the international visitors with other languages. This is because each museum should target specific local and international visitors. The language(s) of the visitors should be catered for when considering the languages of exhibits and the museum. For example, the international visitors may have a predominance of English, either as a first or second language; the exhibits should provide some information in English as the major international language.

The ISTE in museums of the future need to have a
greater capability to show a list of the glossary terms on the visitors’ mobile phones. This will support visitors’ accessing the information of scientific words conveniently. For example, if the visitors unexpectedly do not understand any scientific word on the graphic panel, they can directly access the glossary through the museum’s website or using their mobile phone to scan the code on that graphic panel.

4. **Visual cultures:**

An ISTE should provide a visual image on its graphic panel which can communicate to visitors. The rationale is that this should help ensure that visitors can understand that image. For example a fire symbol on the graphic panel may confuse visitors into thinking that the object is hot. Some ISTEs including images of girls may encourage female visitors to try the exhibits.

The ISTE should provide colour that attracts and motivates visitors to interact with it. Different cultures have different preferences for colour. For example, ISTEs from Germany and European countries are often designed to use few colours and are located in white or black rooms. Compare this with other cultures may use bright colours in more colourful display areas.

The ISTE should reinforce the correct principles of scientific concepts through visual images that the human eye perceives the outside world. The reason for this is to reduce the scientific misconceptions for any visitor. For example, if ISTE demonstrates how people see any object, it should show that the light
enters the eyes from outside rather than the misconceptions that the light comes from the eyes directed onto the objects.

The ISTE should display the object concerned so their proportions relate accurately to one another. The actual size of an object should be conveyed as accurately as possible. This may help young visitors to compare and understand the proportions of the objects in their real world. For example, visitors may believe that small scale spacecraft and astronomical objects of ISTE are actual size.

The ISTE should clearly number each image in order on its graphic panel. The ordering can prevent visitors confusing these images, if it provides a series of visual images or various steps for visitors to follow. For example, Japanese people generally read the series of images in books from right to left.

The ISTE should provide animations without text, if the information is too complicated. Some ISTEs cannot give enough information through only a single image for visitors to understand effectively. For example, several images with animations will help to clarify a description of scientific concept.

5. **Conceptual understanding:**

The ISTE should provide scientific concepts as simple information using a graphic panel. This is because international visitors who may not use English language as their first language may not understand the scientific concepts in the same way as the local
visitors. For example, the definitions of plasma, focus, and gravity should be provided for Thai visitors.

<table>
<thead>
<tr>
<th>The ISTE should offer optional extra information relating to further applications or equipment in everyday life or in cultural usage, in the home country or other countries. Other examples of applications, which may found in the cultural tools/equipment of local and international visitors, can adapt the idea shown in the ISTE. By showing other relevant examples it can help increase conceptual understanding for visitors. For example, if an ISTE includes various mechanical gears, then these could be matched to other examples of usage e.g. bicycle, car, clock, motorcycle, and watches.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ISTE should provide correct scientific concepts connected to the background of local visitors’ culture. This may help local visitors to reduce their cultural misconceptions regarding the ISTE. For example, a supernatural occurrence such as lightning in South Africa could be linked to its concept in science.</td>
</tr>
<tr>
<td>The ISTE should be specifically developed taking into account children and adult misconceptions with any prototype design due to cultural differences. Developing and testing prototypes will improve the ISTE and enable it to support several cultures. For example, children may not be able to perceive concepts of scale in nanoscience and nanotechnology.</td>
</tr>
</tbody>
</table>
### 6. Social issues:

The ISTE should provide visual images, if the aim is for visitors to operate it through social interaction. Operation by social interaction may confuse visitors who have never done this in their culture. For example, if an ISTE needs visitors to shake hands with it, a visual image of a pair of hands shaking should be clearly shown to visitors.

The ISTE should be designed to be operated by multiple visitors if human interaction is desirable. This will help some visitors who have a culture of waiting in a queue, and will create greater human interaction between visitors. For example, ISTEs can be designed in a circular shape to enable visitors to operate it together.

The ISTE should provide visual information which shows that it can be used by more than one visitor. This feature can avoid other visitors waiting in a queue or leaving because they think it is already in use. For example, the social norm of waiting in some cultures may happen more with adults than children.

The ISTE should take account of visitors’ expectations regarding the switching on of exhibits, or start of a presentation. The reason is some people are self-confident and inquisitive, and they will go ahead. As a result they will find how to operate it successfully. Other foreigners who are more reluctant would commonly stand and stare. For example, the location of the on/ start function on the ISTE must be obvious visually, and the operation to start/ switch on must be
clearly labelled on this switch e.g. lift up to start.

The ISTE should use as universally understood protocols as possible. This reason can reduce visitors’ misunderstanding when operating ISTEs. For example, an exhibit called the ‘Real Image’ requires visitors to ‘shake their hand’ within its concave part. The instruction to ‘shake hands’ could be replaced by an instruction for the visitor to move their hand towards the concave reflection bowl.

The museum should have a simple concise message on entry encouraging hands on usage. ISTEs are designed to be touched and operated to get the most out of a visit. For example, parents need to encourage their children to touch and use them.

Any museum staff or volunteer teaching visitors at an ISTE, either directly or on video or via internet, should be older rather than younger. Many societies have strong social norms regarding the young staff teaching their elder. For example, it may be impolite for a young person to teach an older person in some cultures such as in South Africa.

7. Emotional values:

The ISTE should be developed to fulfil any visitors’ emotional aspirations e.g. awe, enjoyment, entertainment, excitement, happiness, satisfaction, and surprise. The aim of this is to encourage these positive emotional responses for many people as possible for as much of the time as possible. For example, young children in most cultures would prefer
ISTEs to provide enjoyment.

The ISTE should seek to generate emotional values for geographical areas containing a range of science exhibits. This will give more opportunities for visitors who have different cultural backgrounds to learn from ISTEs in selected emotional environments. For example, there could be areas based on: excitement, fear, doubt, and happiness.

Colour should be used meaningfully both on ISTE galleries and for museum interiors. This is because different cultures have varying meanings associated with particular colours. For example, Western-European culture commonly finds that blue creates a sensation of ‘cool’ and orange creates a sensation of ‘warmth’.

### 8. Age issues:

Some ISTEs may require supervision of their operation by young or older people, so they should be reminded of this using both a caution symbol and a text label on the ISTE so it is clearly seen. This is because these groups of visitors may not be able to operate one or more features of an ISTE by themselves. For example, one ISTE studied had a rotating seat which was not suitable for use by infirm visitors, those pregnant or with high blood pressure.

The ISTE should offer a seat in a suitable position for older people, with an ergonomic design. Expectations of the elderly vary according to different cultures and physical aids such as seats can help prevent
accidents with older people. For example, seats should be provided if any ISTE requires visitors to stand up to operate it for a long time.

The ISTE should provide a stool or platform which will ensure correct and safe postures are adopted by young children. Not all cultures presently take much interest in children when designing exhibits. For example, an ISTE may require children to operate it at too high a position, while they are standing.

When special glasses are required when using an ISTE, these should fit the complete range of head and facial sizes. This will ensure that young visitors who have a small head can comfortably operate the ISTE, without 3D-glasses or safety glasses having to be held on by the visitors' hands.

All graphics, text, and digital images should take account of the limitations in visual acuity of the elderly – e.g. character sizes, image background, colour contrast. This improvement may help several ages of visitors from different cultural backgrounds. It will also make it easier to read the details of alphabets which might have small symbols than the English alphabet. For example, the exhibits should provide a suitable size and light-coloured fonts for old visitors or visually impaired to read.

9. Gender issues:

The ISTE should if necessary provide optional features for visitors so that different genders can interact with it. Some visitors, such as those who wear
a hijab, may be unwilling to show their face in public. This may prevent them using an exhibit that e.g. produces morphing of a face. In this case, the ISTE should provide a curtain which can be pulled down over the top half of the body, and which can be locked from inside by the visitor. Also, the curtain should show the symbols and text information e.g. ‘Please do not disturb!’ or ‘I am now using this exhibit!’

The ISTE should be at a proper height for visitors’ operation, and suitable for different genders. Certain clothing may affect visitors’ interactions with ISTEs, for some cultures in particular. One example may be a woman who wears a loose collar blouse and needs to bend forward to operate the ISTE. This may result in immodesty. Another example is an exhibit with low seat that requires cycling. If a seat is in too low a position, it will not be suitable in some cultures - e.g. Indian and Thai - for a female who is wearing a skirt, since they will feel shameful. These examples illustrate that an improperly designed ISTE may mean that gender specific issues may stop visitors operating the ISTE.

The ISTE should have a safe design taking into account typical national dress. Different nationalities and genders wear diverse costumes according to their cultural background. For example, the ISTE should not have sharp corners which could pull or hook a long skirt or a long costume worn by female visitors. Also headscarves, loose long hair, and neck ties may become trapped in exhibits.

The ISTE should require a force for operation which is
suitable for different genders based on their physical strength. The rationale behind this is that men are usually stronger than women. For example, if an ISTE has a handle, it should be easily rotated by female visitors using a force which is within their capabilities.

The ISTE should provide engagement for visitors’ operation which appeals to both genders. This will help both genders feel motivated and comfortable when using the ISTE. For example, an ISTE based on competition between visitors should be demonstrated using both genders.

The ISTE should explain broad aspects of scientific knowledge in order to attract different genders. Boys and girls are interested in different perspectives on scientific concepts. For example, competition may appeal to boys more than girls. In this way an exhibit focused on power generation should appeal to a wider range of visitors.

10. Disabled people:

To support disabled people, the ISTE should be designed so that it is as accessible by disabled people as it is by normal visitors.

Blind visitors

The ISTEs should offer an additional means of interaction for blind visitors. Blind persons will not be able to directly access ISTEs through their sense of sight. For example, a blind visitor could physically touch the surface of a model water wave, and interact
with it in this way.

The ISTE should provide blind visitors with Braille text and/or a speech output. Audio equipment should be provided for local and international blind visitors on entry to the museum. For example, headphones with a suitable ‘jack’ may be provided that connect to the ISTE sound system. A more sophisticated system would be one which uses a wireless audio link to the system.

**Deaf visitors**

Any multi-media display incorporating a speaker ISTE(s) should have an optional feature for hand-signage by a human or by virtual human. In this way, deaf visitors could also interact with ISTE. It is now possible for 3D graphics to translate spoken language to hand-signage.

An optional feature would be to offer international hand-signage languages, and in such a way that it is accessible to large groups of visitors at the same time. This would support international groups of deaf visitors. For example, the museum could provide Wi-Fi based systems for the digital-portable devices such as tablets, and mobile-phones.

**Wheel chair visitors**

The ISTE should be designed to support any visitors sitting in a wheelchair. An ISTE should provide a convenient position for these visitors so they can sit directly in front and close to the ISTE. For example, an ISTE needs to be designed so that a visitor in a wheelchair can place their legs under the exhibit.
If an ISTE provides a stool which is necessary for children to stand on and manipulate this ISTE, this causes a problem for wheelchair users. The wheelchair users are at a lower height and may not see the ISTE clearly. In this case, any stool should be low in height, and/or wheelchair access should be provided (see below).

The ISTE should have sufficient space to allow access by wheelchair users. A raised area would support wheelchair users. A slope should be provided for wheelchair access to a raised platform.

Note: Please read other academic resources of universal design which provide more information about the design for disabled people to access in the public area.
References


Ekman, P., Friesen, W.V., O’Sullivan, M., Diacoyanni-Tarlatzis, I., Krause, R., Pitcairn, T., Scherer, K., Chan, A., Heider, K., Ayhan LeCompte, W., Ricci-


References


Teaching Commons (2013). Types of Rubrics. [online]. [viewed 7/12/2013]. Available from:


Appendix 1: Poster describing the cultural issues relating to ISTEs.
(This poster was in A3 size for the reading of the 16 PGCE students).
Appendix 2: Likert Scale in 7-point response scales with the 56 interactive science and technology exhibits.

It shows the table of the Likert Scale as a 7-point response scale with the 56 science interactive exhibits of the NSM in Thailand with 11 characteristics by the author, Sumath Awsakulsutthi.


[Criteria for rating each interactive science and technology exhibits for each of the characteristics adapted from Vagias (2006): 1 = Not present, 2 = Very slightly present, 3 = Slightly present, 4 = Average presence, 5 = Strongly present, 6 = Always present, 7 = Crucially present].

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1. Pulleys make lifting easier</td>
<td></td>
<td>7 7 6 5</td>
<td>7 1 6 1 5 7 7</td>
<td></td>
</tr>
<tr>
<td>2. Gravity and plants</td>
<td></td>
<td>7 7 5 5</td>
<td>6 6 4 5 6 1 6</td>
<td></td>
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<tr>
<td>3. Newton and the apple</td>
<td></td>
<td>7 7 6 5</td>
<td>7 6 4 2 5 6 7</td>
<td></td>
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<tr>
<td>4. The Bernoulli principle</td>
<td></td>
<td>7 7 7 6</td>
<td>7 5 4 6 4 1 7</td>
<td></td>
</tr>
<tr>
<td>5. Gears and how they work</td>
<td></td>
<td>7 7 6 4</td>
<td>7 1 5 6 5 6 6</td>
<td></td>
</tr>
<tr>
<td>6. Centrifuge</td>
<td></td>
<td>7 7 7 6</td>
<td>7 5 4 1 6 7 4</td>
<td></td>
</tr>
<tr>
<td>7. Gravity and the solar system</td>
<td></td>
<td>7 7 5 4</td>
<td>5 6 7 1 5 1 6</td>
<td></td>
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<tr>
<td>8. Down the slippery slope</td>
<td></td>
<td>7 7 6 5</td>
<td>6 7 5 2 6 5 6</td>
<td></td>
</tr>
<tr>
<td>9. Send the train on its way</td>
<td></td>
<td>7 7 4 4</td>
<td>5 6 7 6 5 1 5</td>
<td></td>
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<tr>
<td>10. Make the wheels turn more easily</td>
<td></td>
<td>7 7 5 5</td>
<td>6 6 5 2 5 6 1</td>
<td></td>
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<tr>
<td>11. Useful friction</td>
<td></td>
<td>7 7 5 6</td>
<td>7 6 5 4 5 6 1</td>
<td></td>
</tr>
<tr>
<td>12. Magnetic forces – attraction and repulsion</td>
<td></td>
<td>7 7 4 5</td>
<td>6 6 5 5 5 1 1</td>
<td></td>
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<tr>
<td>13. Electromagnets</td>
<td></td>
<td>7 7 5 6</td>
<td>6 5 6 6 5 1 1</td>
<td></td>
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<tr>
<td>14. Spin the coil – generate electricity</td>
<td></td>
<td>7 7 5 6</td>
<td>6 1 5 6 5 7 7</td>
<td></td>
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<tr>
<td>15. Electricity from the sun</td>
<td></td>
<td>7 7 5 5</td>
<td>4 5 7 6 5 7 7</td>
<td></td>
</tr>
<tr>
<td>16. Batteries</td>
<td></td>
<td>7 7 5 5</td>
<td>5 5 6 6 5 7 6</td>
<td></td>
</tr>
<tr>
<td>17. Bulbs and batteries</td>
<td></td>
<td>7 7 5 5</td>
<td>5 5 6 6 5 1 6</td>
<td></td>
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</tbody>
</table>
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<tr>
<th></th>
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<tbody>
<tr>
<td>18 Static electricity</td>
<td>1 2 3 4 5 6 7 8 9 10 11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 How hot are you?</td>
<td>7 7 5 6 7 6 5 5 5 7 1</td>
<td></td>
<td></td>
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<tr>
<td>20 Heat on the move/convection</td>
<td>7 7 4 5 4 6 7 5 5 1 6</td>
<td></td>
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<tr>
<td>21 Heat on the move/conduction</td>
<td>7 7 4 6 6 6 7 5 5 7 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 Heat on the move/radiation</td>
<td>7 7 6 5 6 6 7 5 6 7 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 Plasma ball</td>
<td>7 7 6 7 4 6 7 7 7 7 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 The elements in water</td>
<td>7 7 6 7 5 5 7 7 6 1 7</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>25 Crystals</td>
<td>6 7 3 4 5 6 7 2 5 1 1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>26 Fluidised bed</td>
<td>7 7 6 7 7 4 7 5 7 5 7</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>27 Multiplication</td>
<td>7 7 5 6 5 5 7 6 5 1 7</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>28 Addition – how fast are you?</td>
<td>7 7 6 6 7 6 7 5 5 1 1</td>
<td></td>
<td></td>
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<tr>
<td>29 Pythagorus–father of geometry</td>
<td>7 7 7 7 7 5 5 4 5 1 6</td>
<td></td>
<td></td>
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<tr>
<td>30 Counting</td>
<td>7 7 5 6 7 7 7 5 5 1 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 Geometry – measuring angles</td>
<td>7 7 5 6 6 2 7 1 5 1 1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>32 Measuring volume</td>
<td>7 7 4 5 5 2 7 3 5 1 5</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>33 How far? – measuring distance</td>
<td>7 7 2 5 6 5 7 6 6 1 1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>34 Camera obscura</td>
<td>7 7 7 6 6 6 6 4 6 1 5</td>
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<td></td>
<td></td>
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<tr>
<td>35 Pepper’s ghost</td>
<td>7 7 7 6 6 3 6 5 6 1 7</td>
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<td></td>
<td></td>
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<tr>
<td>36 Optical fibres</td>
<td>7 7 7 6 6 5 6 6 6 4 7</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>37 Lenses</td>
<td>7 7 6 6 6 5 6 6 6 4 7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Interactive Science and Technology Exhibits (ISTEs)</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Coloured light</td>
<td>7</td>
</tr>
<tr>
<td>Shadow on Screen</td>
<td>7</td>
</tr>
<tr>
<td>Speaking dishes</td>
<td>7</td>
</tr>
<tr>
<td>Echo chamber</td>
<td>7</td>
</tr>
<tr>
<td>Speaking tubes</td>
<td>7</td>
</tr>
<tr>
<td>Sound waves and musical notes</td>
<td>7</td>
</tr>
<tr>
<td>Musical notes – percussion</td>
<td>7</td>
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<tr>
<td>The power of the earth</td>
<td>7</td>
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<tr>
<td>Solar power</td>
<td>7</td>
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<tr>
<td>Nuclear power</td>
<td>7</td>
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<tr>
<td>Fossil power</td>
<td>7</td>
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<tr>
<td>Wind power</td>
<td>7</td>
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<tr>
<td>Water power</td>
<td>7</td>
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<tr>
<td>Human power</td>
<td>7</td>
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<tr>
<td>Real image</td>
<td>7</td>
</tr>
<tr>
<td>Vocal Vowels</td>
<td>7</td>
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<tr>
<td>Talk Tripper</td>
<td>7</td>
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<tr>
<td>Hyperbola</td>
<td>7</td>
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<tr>
<td>Short Measure</td>
<td>6</td>
</tr>
</tbody>
</table>

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Appendix 3: Online survey in Case study 1
Appendix 3 (continued): Online survey in Case study 1

PART 1: Cultural issues of interactive science exhibits

*See the same poster in Appendix 1 of this Thesis.*

Cultural Issues

The current understanding of relevant cultural issues is shown. Six areas of concern in relation to cultural issues have been identified:
- Manual skills
- Technologies issues
- Language issues
- Visual cultures
- Conceptual understanding
- Social issues

8. Do you believe that these areas are potentially significant in relation to cultural issues?

- Yes
- No

Please look at these images of the six exhibits and answer question 9.

<table>
<thead>
<tr>
<th>Exhibit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Manual skills: Static electricity (See 16)</td>
</tr>
<tr>
<td>2.</td>
<td>Technologies issues: Electricity from the sun (See 15)</td>
</tr>
<tr>
<td>3.</td>
<td>Language issues: Fluidised bed (See 26)</td>
</tr>
<tr>
<td>4.</td>
<td>Visual cultures: Vocal Vowels (See 53)</td>
</tr>
<tr>
<td>5.</td>
<td>Conceptual understanding: Popper's ghost (See 35)</td>
</tr>
<tr>
<td>6.</td>
<td>Social issues: Real image (See 53)</td>
</tr>
</tbody>
</table>

9. Identified areas of potential cultural issues are:

<table>
<thead>
<tr>
<th>Issue Description</th>
<th>Do you believe there are cultural issues?</th>
<th>Which exhibits in Appendix 1 of this type? (Please specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Manual skills such as Static electricity (See 16) How people rub different materials in their cultural way? For example, Thai people use a knife to cut something away from their body.</td>
<td>Yes No</td>
<td></td>
</tr>
<tr>
<td>b. Technologies issues such as Electricity from the sun (See 15) How people turn on the electric switch in their countries?</td>
<td>Yes No</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 3 (continued): Online survey in Case study 1

PART 2: Taxonomies of interactive science exhibits

1. Research strategy for categorisation:

It is necessary to categorise the exhibit in order to be able to develop design guidelines. The approach taken in summarised in the taxonomies of interactive science exhibits paper.

12. Do you agree that this is the most appropriate research strategy?
   - Yes
   - No

13. Can you suggest any improvements? (Optional)

2. Previous categorisation methods

(Read pages 1-4 of the taxonomies of interactive science exhibits paper.)

Three methods have been identified: Ghose (2000), Gilbert and Stockmayer (2001) and Sandifer (2003), which are described in the attached paper. However, these do not appear to result in useful groupings for experimental design if the exhibits can be placed in more than one group.

14. Do you agree that none of the previously published approaches can be used?
   - Yes
   - No

15. If 'No' which approach do you believe could work? Can you also indicate why?
Appendix 3 (continued): Online survey in Case study 1

3. New categorization method

To explore cluster analysis, the exhibits have been placed in categories for statistical analysis. This method requires criteria to be ranked using a Likert scale. The criteria chosen are ranked using the scale indicated below.

<table>
<thead>
<tr>
<th>Criteria for rating each interactive science exhibit, for each of the characteristics</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not present</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Very slightly present</td>
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<tr>
<td>Slightly present</td>
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<tr>
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<td>Strongly present</td>
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<tr>
<td>Always present</td>
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<tr>
<td>Crucially present</td>
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</tr>
</tbody>
</table>

(Adapted the 7-point response scales from Vaghas, Wade M., 2006)

16. Do you agree with this choice of criteria?

- Yes
- No

17. Do you agree with the scale descriptors? (Optional)

- Yes
- No

(Read pages 3-4 of the taxonomies of interactive science exhibits paper.)

The 4 exhibits below have been given the numbers as they appear in the Appendix of the taxonomies of interactive science exhibits paper. Please rank them by selecting in an appropriate circle on each characteristic as follows.

**Magnetic forces -- attraction and repulsion (12)**

The exhibit has 4 different sizes of the magnets. Each magnet is glued under the same size of plastic piece. The visitors can move these magnetic pieces around or touch them on any surface of the different materials such as plywood, brass, iron, stainless steel, and Formica.

18. Please rank the Magnetic forces -- attraction and repulsion (12)

<table>
<thead>
<tr>
<th>Select any appropriate circle on each characteristic</th>
<th>Not present</th>
<th>Very slightly present</th>
<th>Slightly present</th>
<th>Average presence</th>
<th>Strongly present</th>
<th>Always present</th>
<th>Crucially present</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Two-way communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Multiplicity</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>c. Discovery process</td>
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</tr>
</tbody>
</table>
Appendix 3 (continued): Online survey in Case study 1

<table>
<thead>
<tr>
<th>d. Simulated situation</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>e. A simple demonstration of a phenomenon</td>
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<tr>
<td>f. Matching both a real-world phenomenon and the consensus model</td>
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<tr>
<td>g. A ‘For’ analogy to represent the consensus model</td>
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<tr>
<td>h. Technologically novel</td>
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<tr>
<td>i. Open-ended</td>
<td></td>
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<tr>
<td>j. User-centred</td>
<td></td>
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<tr>
<td>k. Stimulates the senses</td>
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</tbody>
</table>

Gravity and plants (2)

The visitors can look up at the Gravity and plants exhibit. This exhibit has a metal bar which rotates. This negates the effect on plant growth and the plants grow horizontally.

19. Please rank the Gravity and plants (2)

<table>
<thead>
<tr>
<th>Select any appropriate circle on each characteristic</th>
<th>Not present</th>
<th>Very slightly present</th>
<th>Slightly present</th>
<th>Average presence</th>
<th>Strongly present</th>
<th>Always present</th>
<th>Crucially present</th>
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<tbody>
<tr>
<td>a. Two-way communication</td>
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<tr>
<td>c. Discovery process</td>
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<td>d. Simulated situation</td>
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<tr>
<td>e. A simple demonstration of a phenomenon</td>
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<tr>
<td>f. Matching both a real-world phenomenon and the consensus model</td>
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</tbody>
</table>
Appendix 3 (continued): Online survey in Case study 1

Useful friction (13)

The exhibit has a wheel (A) and a metal disc (B) for rotation. The visitor can turn a black disc (C) to rotate the wheel. It has a handbrake (D) on the right hand side of the black disc (C). The visitor can grab this handbrake (D) to stop the wheel (A)'s rotation. The visitor can wind a small disc (E) to rotate a metal disc (B) which can be paused by pushing the button (F).

20. Please rank the Useful friction (13)

<table>
<thead>
<tr>
<th>Select any appropriate circle on each characteristic</th>
<th>Not present</th>
<th>Very slightly present</th>
<th>Slightly present</th>
<th>Average presence</th>
<th>Strongly present</th>
<th>Always present</th>
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<td>c. Discovery process</td>
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<tr>
<td>d. Simulated situation</td>
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<tr>
<td>e. A simple demonstration of a phenomenon</td>
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<tr>
<td>g. A 'far' analogy to represent the consensus model</td>
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</tr>
<tr>
<td>h. Technologically novel</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>
Appendix 3 (continued): Online survey in Case study 1

PART 1: Cultural issues of interactive science exhibits
(Read the cultural issues from the attached poster.)

See the same poster in Appendix 1 of this Thesis.

Cultural Issues

The current understanding of relevant cultural issues is shown. Six areas of concern in relation to cultural issues have been identified:

- Manual skills
- Technologies issues
- Language issues
- Visual cultures
- Conceptual understanding
- Social issues

8. Do you believe that these areas are potentially significant in relation to cultural issues?
   - Yes
   - No

Please look at these images of the six exhibits and answer question 9:

<table>
<thead>
<tr>
<th>Exhibit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Manual skills</td>
<td>Static electricity (See 18)</td>
</tr>
<tr>
<td>2. Technologies issues</td>
<td>Electricity from the sun (See 15)</td>
</tr>
<tr>
<td>3. Language issues</td>
<td>Fluidised bed (See 26)</td>
</tr>
<tr>
<td>4. Visual cultures</td>
<td>Vocal Vowels (See 53)</td>
</tr>
<tr>
<td>5. Conceptual understanding</td>
<td>Pepper's ghost (See 35)</td>
</tr>
<tr>
<td>6. Social issues</td>
<td>Real Image (See 53)</td>
</tr>
</tbody>
</table>

9. Identified areas of potential cultural issues are:

<table>
<thead>
<tr>
<th>Area</th>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Manual skills such as Static electricity (See 18)</td>
<td>How people rub different materials in their cultural way? For example, Thai people use a knife to cut something away from their body.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Technologies issues such as Electricity from the sun (See 15)</td>
<td>How people turn on the electric switch in their countries?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 3 (continued): Online survey in Case study 1

(Read page 7-12 of the taxonomies of interactive science exhibits paper)

Interactive Science Exhibits

Simple interaction

Direct understanding

Examples

Magnetic forces - attraction and repulsion (See 7)

Complex understanding

Examples

Magnetism and electricity (See 4)

Multiple interactions

Direct understanding

Examples

Speech tubes (See 40)

Complex understanding

Examples

Plasma ball (See 29)

Wind power (See 48)

Neuron and the apple (See 3)

22. Do you believe that these 4 groups’ descriptions can be form a new classification approach?

- Yes
- No

23. Can you make any suggestions in order to improve these descriptors? (Optional)

Please click ‘continue’ as belows to go to the last page with no questions and finish this feedback.

Continue >

Survey testing only

Check Answers & Continue >
**Appendix 4: Overlapped categories in the existing classifications**

The difficulty of placing the examples from the 56 interactive science and technology exhibits at the NSM, Thailand in unique categories of the existing classifications is shown in the following table.

<table>
<thead>
<tr>
<th>Characteristics of interactive science exhibits</th>
<th>Notes</th>
<th>The examples can be placed in more than one group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Two-way communication</td>
<td>Hands-on exhibits are operated by visitors in different ways such as visitors interacting with questions generated by the exhibit (Ghose, 2000).</td>
<td><strong>Vocal Vowels</strong> <em>(See 53 in Appendix 1)</em></td>
</tr>
<tr>
<td>2. Multiplicity or multiple operation</td>
<td></td>
<td>The visitors can interact in a multiplicity of ways e.g. if they pump the wind to blow their hands. They do not pump the wind directly to the vocal vowels as two-way communication.</td>
</tr>
<tr>
<td>3. Discovery process</td>
<td>Minds-on exhibits where visitors can discover by themselves or cross time and space in a simulated situation (Ghose, 2000).</td>
<td><strong>Vocal Vowels</strong> <em>(See 53 in Appendix 1)</em></td>
</tr>
<tr>
<td>4. Simulated situation</td>
<td></td>
<td>The visitors can try to discover the different vocal vowels by their own experiment. The exhibit also offers a simulated situation such as why most animals cannot speak.</td>
</tr>
</tbody>
</table>
Appendix 4 (continued):
The difficulty of placing the examples from the 56 interactive science and technology exhibits at the NSM, Thailand in unique categories of the existing classifications is shown in the following table.

<table>
<thead>
<tr>
<th>Characteristics of interactive science exhibits</th>
<th>Notes</th>
<th>The examples can be placed in more than one group.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. A simple demonstration of a phenomenon</td>
<td>1. “...Beyond the instructions about what to do, the graphics associated with this type of exhibit tend to be couched in terms of the consensus model... A valuable outcome of the use of such an exhibit would be an appreciation that a phenomenon is found in more than one context and, perhaps, that an explanatory consensus model exists” (Gilbert and Stocklmayer, 2001, p. 46-47).</td>
<td>Water power (See 50 in Appendix 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>It is a simple way to produce the water waves as in nature.</td>
</tr>
<tr>
<td>6. Matching both a real-world phenomenon and the consensus model</td>
<td>2. “...the exhibit shows a direct physical similarity to both the phenomenon and to the consensus model of it...Strong links will be formed between the ‘experience’ and the ‘target’ ” (Gilbert and Stocklmayer, 2001, p. 47). In addition, Gilbert and Stocklmayer (2001, p. 42) defined “the experience which is the activity provided by the interactive exhibit’, and ‘the target, the phenomenon or idea which is of interest to science or a technological artefact which is of interest to society”.</td>
<td>Water power (See 50 in Appendix 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The exhibit shows the water waves in a transparent acrylic tank. It demonstrates how the wave energy can be used in the real world.</td>
</tr>
</tbody>
</table>
Appendix 4 (continued):
The difficulty of placing the examples from the 56 interactive science and technology exhibits at the NSM, Thailand in unique categories of the existing classifications is shown in the following table.

<table>
<thead>
<tr>
<th>Characteristics of interactive science exhibits</th>
<th>Notes</th>
<th>The examples can be placed in more than one group.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. A ‘far’ analogy to represent the consensus model</td>
<td>3. “When using exhibits in this group, the visitor is expected both to understand the analogical representation and make inferences about a target that is ‘far’ from the source of the analogy. Meeting a new exhibit and deciding to engage with it involves several factors” (Gilbert and Stocklmayer, 2001, p. 47).</td>
<td>Water power (See 50 in Appendix 1) The water surface in the tank of the exhibit impacts on a dynamo. The dynamo generates an electricity to turn on the light.</td>
</tr>
<tr>
<td>8. Technologically novel</td>
<td>“...if it met at least one of the following criteria: 1. The exhibit contained visible state-of-the-art devices. 2. The exhibit, through the use of technology, illustrated phenomena that would otherwise be impossible or laborious for visitors to explore on their own” (Sandifer, 2003, p. 127).</td>
<td>Optical fibres (See 36 in Appendix 1) The optical fibres are used in communication technology and network systems (Rawson and Metcalfe, 1978).</td>
</tr>
<tr>
<td>9. Open-ended</td>
<td>“...if it met at least one of the following criteria: 1. The exhibit allowed for the achievement of multiple visitor-set goals. 2. The exhibit allowed for one goal to be achieved in multiple ways” (Sandifer, 2003, p. 128).</td>
<td>Optical fibres (See 36 in Appendix 1) The visitors can find out how the optical fibres transmit light.</td>
</tr>
</tbody>
</table>
**Appendix 4 (continued):**

The difficulty of placing the examples from the 56 interactive science and technology exhibits at the NSM, Thailand in unique categories of the existing classifications is shown in the following table.

<table>
<thead>
<tr>
<th>Characteristics of interactive science exhibits</th>
<th>Notes</th>
<th>The examples can be placed in more than one group.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. User-centred</td>
<td>“…if the outcome of the exhibit manipulation involved a representation of or an effect on the user’s body or voice” (Sandifer, 2003, p. 128).</td>
<td><em>Shadow on Screen (See 39 in Appendix 1)</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The visitors can see themselves as shadows on the screen.</td>
</tr>
<tr>
<td>11. Stimulates the senses</td>
<td>“…if it met at least one of the following criteria: 1. The exhibit emitted sounds on its own or when in use. 2. The exhibit had one or more visible parts, objects, or images that moved on their own or when the exhibit was in use. 3. The exhibit had lights that blinked or flashed on their own or when the exhibit was in use” (Sandifer, 2003, p. 128).</td>
<td><em>Shadow on Screen (See 39 in Appendix 1)</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The exhibit emits a flashing light illuminating the visitors and the screen.</td>
</tr>
</tbody>
</table>
**Appendix 5: The groups are formed by the cluster analysis**

Classify using Ghose’s (2000) approach in 4 groups (Group A) as follows.

**Group A1** (28 exhibits): 4, 6, 11, 13, 14, 18, 19, 21, 23, 24, 26, 27, 28, 29, 30, 31, 34, 35, 36, 37, 38, 39, 40, 44, 46, 52, 53, 55

The common characteristics of this group **cannot be identified**. Because there are conflict idea between two way communication and multiplicity of the Hands-on interactive exhibits of Ghose (2000). Because these exhibits can become to both ‘multiplicity’ and ‘two-way communication’. If no museum staff explains to the visitors how to participate with these exhibits as ‘two-way communication’, the visitors can interact by their own idea as ‘multiplicity’.

**Group A2** (21 exhibits): 1, 2, 3, 5, 7, 8, 9, 10, 12, 15, 16, 17, 20, 22, 32, 33, 41, 43, 45, 47, 48

The common characteristics of this group **cannot be identified**. Because there are conflict idea between two way communication and multiplicity of the Hands-on interactive exhibits of Ghose (2000). Because these exhibits can become to both multiplicity and two-way communication. If no museum staff explains to the visitors how to participate with these exhibits as two-way communication, the visitors can interact by their own idea as multiplicity.

**Group A3** (5 exhibits): 42, 50, 51, 54

This group is in ‘two way communication’.

**Group A4** (2 exhibits): 25, 56

This group is ‘multiplicity’.
Appendix 5 (continued): The groups are formed by the cluster analysis

Classify using Gilbert and Stocklmayer's (2001) approach in 3 groups (Group B).

Group B1 (21 exhibits):
1, 5, 13, 14, 16, 17, 31, 32, 35, 36, 37, 39, 40, 42, 43, 44, 47, 52, 54, 55, 56

This group is a simple demonstration of a phenomenon such as 1, 5, 13, 17, 31, 32, 35, 36, 37, 39

Only 47, 54, 55, 56 of this group is a far analogy to represent the consensus model.

Group B2 (24 exhibits):
7, 9, 15, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 33, 34, 38, 41, 45, 46, 48, 49, 50, 53

This group is a far analogy to represent the consensus model such as 7, 9, 15, 20, 21, 22, 23, 24, 25, 26, 27, 33, 45, 48

Others cannot be identified because they can become both a simple demonstration of a phenomenon and a far analogy to represent the consensus model because most of them are in the same ranking.

Group B3 (11 exhibits):
2, 3, 4, 6, 8, 10, 11, 12, 19, 29, 51

This group is a simple demonstration of a phenomenon.
Appendix 5 (continued): The groups are formed by the cluster analysis

Classify using Sandifer's (2003) approach in 4 groups (Group C).

Group C1 (13 exhibits):
7, 12, 13, 18, 25, 28, 30, 31, 33, 47, 48, 55, 56

13, 28, 30, 33, 47, 56 of this group are in 'Technologically Novel' but others can be classified as 'Open-ended or Technologically Novel'.

Group C2 (14 exhibits):
2, 4, 9, 17, 20, 24, 27, 29, 32, 34, 35, 46, 49, 50

2, 32, 34, 35, 46, 49, 50 of this group are in 'Open-ended'. 9, 17, 24 are in 'Technologically Novel'. 4, 20, 27, 29 are in 'Stimulates the Senses'.

Group C3 (13 exhibits):
1, 3, 6, 8, 10, 11, 19, 21, 22, 40, 41, 42, 53

6, 10, 11, 19, 21, 22, 40, 41, 42, 53 are in 'User-Centred'. 1, 3, 8 are in 'Stimulates the Senses'.

Group C4 (16 exhibits):
5, 14, 15, 16, 23, 26, 36, 37, 38, 39, 43, 44, 45, 51, 52, 54

36, 37, 38, 39, 43, 44 of this group are in 'Stimulates the Senses'. Others cannot be identified because they are in same scale of the other characteristics.
Appendix 5 (continued): The groups are formed by the cluster analysis

A+B and B+C are not useful classifications because the characteristics of the members of the clusters cannot be identified. They appear to be mixed in other groups and not follow the methods of classifying interactive exhibits in the literature review. A + B + C shows the same issues, but is reported better as follows.

Group (A + B + C) 1
(13 exhibits):
23, 24, 26, 34, 35, 36, 37, 38, 39, 40, 44, 46, 52
The common characteristics of this group cannot be identified. Because 3-4 characteristics are in the same ranking.

Group (A + B + C) 2
(24 exhibits):
1, 2, 3, 4, 5, 6, 8, 10, 11, 12, 13, 14, 18, 19, 21, 22, 28, 29, 30, 31, 32, 41, 53, 55
The common characteristics of this group cannot be identified. Because 3-4 characteristics are in the same ranking.

Group (A + B + C) 3
(5 exhibits):
42, 49, 50, 51, 54
cannot be identified

Group (A + B + C) 4
(12 exhibits):
7, 9, 15, 16, 17, 20, 27, 33, 43, 45, 47, 48
The common characteristics of this group cannot be identified. Because 3-4 characteristics are in the same ranking.

Group (A + B + C) 5
(2 exhibits): 25, 56
Cannot be identified
### Appendix 6: The 56 ISTE in the new classifications

<table>
<thead>
<tr>
<th>Group 1: Simple interaction with direct understanding (14 exhibits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Gravity and plants</td>
</tr>
<tr>
<td>4. The Bernoulli principle</td>
</tr>
<tr>
<td>9. Send the train on its way</td>
</tr>
<tr>
<td>17. Bulbs and batteries</td>
</tr>
<tr>
<td>20. Heat on the move/convection</td>
</tr>
<tr>
<td>24. The elements in water</td>
</tr>
<tr>
<td>27. Multiplication</td>
</tr>
<tr>
<td>29. Pythagoras—father of geometry</td>
</tr>
<tr>
<td>32. Measuring volume</td>
</tr>
<tr>
<td>34. Camera obscure</td>
</tr>
<tr>
<td>35. Pepper's ghost</td>
</tr>
<tr>
<td>46. Solar power</td>
</tr>
<tr>
<td>49. Wind power</td>
</tr>
<tr>
<td>50. Water power</td>
</tr>
</tbody>
</table>
**Appendix 6 (continued): The 56 ISTEs in the new classification**

**Group 2: Simple interaction with complex understanding (13 exhibits)**

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Image" /></td>
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<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
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</tbody>
</table>

<table>
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<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image9.png" alt="Image" /></td>
<td><img src="image10.png" alt="Image" /></td>
<td><img src="image11.png" alt="Image" /></td>
<td><img src="image12.png" alt="Image" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>56. Short measure</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image13.png" alt="Image" /></td>
</tr>
</tbody>
</table>

408
### Appendix 6 (continued): The 56 ISTEs in the new classification

#### Group 3: Multiple interactions with direct understanding (13 exhibits)

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>22. Heat on the move/radiation</td>
<td>40. Speaking dishes</td>
<td>41. Echo chamber</td>
<td>42. Speaking tubes</td>
</tr>
<tr>
<td>53. Vocal Vowels</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Appendix 6 (continued): The 56 ISTES in the new classification

<table>
<thead>
<tr>
<th>Group 4: Multiple interactions with complex understanding (16 exhibits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Gears and how they work</td>
</tr>
<tr>
<td>14. Spin the coil – generate electricity</td>
</tr>
<tr>
<td>15. Electricity from the sun</td>
</tr>
<tr>
<td>16. Batteries</td>
</tr>
<tr>
<td>23. Plasma ball</td>
</tr>
<tr>
<td>26. Fluidised bed</td>
</tr>
<tr>
<td>36. Optical fibres</td>
</tr>
<tr>
<td>37. Lenses</td>
</tr>
<tr>
<td>38. Coloured light</td>
</tr>
<tr>
<td>39. Shadow on Screen</td>
</tr>
<tr>
<td>43. Sound waves and musical notes</td>
</tr>
<tr>
<td>44. Musical notes – percussion</td>
</tr>
<tr>
<td>45. The power of the earth</td>
</tr>
<tr>
<td>51. Human power</td>
</tr>
<tr>
<td>52. Real image</td>
</tr>
<tr>
<td>54. Talk Tripper</td>
</tr>
</tbody>
</table>
### Appendix 7: The experts’ interview results in Case study 1

The interview results compare between two experts - an expert of the Snibston Discovery Museum, UK (20 August 2011) and an expert of the NSM, Thailand on (27 August 2011) in the following table.

<table>
<thead>
<tr>
<th>Interview questions</th>
<th>The UK expert at the Snibston Discovery Museum</th>
<th>The Thai expert at the NSM, Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: What is your name?</td>
<td>Brian Kennedy</td>
<td>Malcolm Bray</td>
</tr>
<tr>
<td>Q2: May I know how old are you?</td>
<td>50</td>
<td>89</td>
</tr>
<tr>
<td>Q3: What is your position at the museum?</td>
<td>Head of Learning</td>
<td>Science Show and Exhibit Design Consultant</td>
</tr>
<tr>
<td>Q4: How long have you worked at the museum?</td>
<td>I’ve worked for over 18 years in museums. 14 years at Snibston</td>
<td>11 years in National Science Museum, Thailand and 10 years at National Science, Canberra, Australia</td>
</tr>
<tr>
<td>Q5: How many visitors visit this museum per year?</td>
<td>106,000 visitors</td>
<td>1 million visitors</td>
</tr>
<tr>
<td>Q6: Do you believe that the cultural issues affect the visitors learning through the interactive science exhibit or not? For example, physical skills, technologies issues, language issues, visual cultures, conceptual understanding and social issues. Why do you think like that?</td>
<td>I do think cultural issues do affect how people engage with interactives. An example might be visitors who use writing systems that read from right to left instead of the western tradition of left to right. This might influence where people look in terms of where information is laid out on an interactive and also if a interactive requires visitors to interact in a sequence then this in a western interactive would probably be laid out left to right. I think also that different cultures may have different views of the physical world and their relationship with it. Some cultures may value technology more which could mean visitors are in general more likely to engage with technology based exhibits.</td>
<td>Yes, cultural issues do affect learning from exhibits. Thailand is not homogeneous. For example, there is a difference in attitude to science in Bangkok major city and Chiang Mai as North agriculture are like different countries when compared with the North and particularly the South high percentage Muslims with low education level of girls. This occurs due to quality of education and culture crossover at borders. There is always a problem when scientific words are used generally. I think this occurs in all languages.</td>
</tr>
</tbody>
</table>
Appendix 7 (continued):

<table>
<thead>
<tr>
<th>Interview questions</th>
<th>The UK expert at the Snibston Discovery Museum</th>
<th>The Thai expert at the NSM, Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q6 (continued):</strong> Do you believe that the cultural issues affect the visitors learning through the interactive science exhibit or not? For example, physical skills, technologies issues, language issues, visual cultures, conceptual understanding and social issues. Why do you think like that?</td>
<td>(As above)</td>
<td>In English, for instance the word “theory” means to the general public an untested idea as to why something happens. Scientifically, it means a tested answer to a scientific question but still open for other scientists to research it to disprove or modify. Language plays a major part with an absence of words for technologies. The meaning of flexibility and elasticity in Thai to the general public is not quite accurate for a material. Like butter is flexible. You can deform it and it stays that way unless you deform it again. It has no shape memory. Elastic materials have a shape memory unless you deform it enough to damage the molecular structure. So I think we just recognise that the code we call language can define thoughts produced by observation in different ways not directly convertible or translatable. That some exhibits on the mobile museum are more popular in one province than another.</td>
</tr>
</tbody>
</table>
Appendix 7 (continued):

<table>
<thead>
<tr>
<th>Interview questions</th>
<th>The UK expert at the Snibston Discovery Museum</th>
<th>The Thai expert at the NSM, Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q7: Do you believe that the cultural issues influent in different gender for interacting with the interactive science exhibits or not? Why do you believe that?</strong></td>
<td>I think it could. From my own cultural background the way interactives are often are presented can make them be viewed as more appealing to boys. In British culture there are still certain classes of objects e.g. large industrial objects that are often seen by society as associated with males rather than females. This can be seen very easily if you visit toy shops where there are still toys designed and sold for boys and others for girls. I assume that there may be similar distinctions in other cultures.</td>
<td>Yes, generally young people do not associate science with everyday life girls less than boys. The difference varies according to cultural thinking. I believe men and women from the same culture react differently when observing the same activity caused by gender difference. Part DNA part training.</td>
</tr>
<tr>
<td><strong>Q8: What are the characteristics of the interactive exhibits which build on cultural differences and affect learning?</strong></td>
<td>I think one example may be whether or not an interactive is designed to be used by one individual or by a group of visitors. There could be cultural difference between how people interact as a group that could affect how an interactive is used and how this might affect what learning people get from the interactive.</td>
<td>Interactive exhibits that use highly technical examples have a poorer chance of connecting with some cultures. Exhibits that demonstrate science with every day articles stand a better chance. Even that does not always work because everyday can depend on culture.</td>
</tr>
<tr>
<td><strong>Q9: What are other factors such as age, gender, and educational level, which significantly relate to cultural differences for learning interactive exhibits?</strong></td>
<td>I think one factor could be the way people behave in public spaces which could be influenced by culture. In other words the accepted social behaviour that is acceptable in a public space. The cultural background of some visitors may determine how they act in public spaces such as museums.</td>
<td>Designing interactive exhibits to demonstrate abstract science such as atoms and molecules can be very difficult multiculturally as the designer has no idea as to the mental picture conceived by different cultures.</td>
</tr>
</tbody>
</table>
### Interview questions

<table>
<thead>
<tr>
<th>Q9 (continued): What are other factors such as age, gender, and educational level, which significantly relate to cultural differences for learning interactive exhibits?</th>
<th>The UK expert at the Snibston Discovery Museum</th>
<th>The Thai expert at the NSM, Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>For instance culture may determine how individuals may seek permission to use exhibits or how they interact with objects that are owned by other people, in this case the museum.</td>
<td>(As above)</td>
<td></td>
</tr>
</tbody>
</table>

| Q10: How can interactive exhibits be developed to avoid the adverse effects of cultural differences? | I think a key to developing any interactive is that the message that an interactive seeks to convey needs to be conceptually simple. Interactives need to use visitors existing experiences of everyday life as the base starting point rather than a specific educational level or an assumption of understanding of a scientific theorem. Visitors must be able to fit the ideas interactives explain into their own understanding of the world around them. I think therefore interactives for the most part should be designed for the typical range of cultures represented by the range of visitors a museum receives and should be tested as prototypes with different types of visitors which would include culture but also gender and age. I think interaction works best when it is simple and this is more likely to appeal to a wider range of cultures. The point is that the interaction can be simple but the conclusions visitors take from the interaction can be quite simple. | It is difficult for first the designer must be aware of cultural differences which in some cases can be somewhat opaque. Even the designer can have difficulty in receiving instructions about other cultures. If a multicultural exhibit is to be designed a multicultural team should do it. |
Appendix 7 (continued):

<table>
<thead>
<tr>
<th>Interview questions</th>
<th>The UK expert at the Snibston Discovery Museum</th>
<th>The Thai expert at the NSM, Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q10 (continued): How can interactive exhibits be developed to avoid the adverse effects of cultural differences?</strong></td>
<td>A good example of this is at ‘Enginuity’, an exhibition at the Ironbridge Gorge Museum, where visitors can use pulleys and gears to pull a train locomotive by hand. In this case the task is simple but each individual visitor can think about what is happening using their own personal knowledge and experience to try and figure how they are able to move such a massive weight. I think this is the type of interactive that can successfully work across cultures.</td>
<td>(As above)</td>
</tr>
</tbody>
</table>
**Appendix 8: Classification of countries by the 6 major areas and regions**

[Retrieved information from the United Nations (2009, p.1-4; 2013, p.85-87) was shown in the following table].

<table>
<thead>
<tr>
<th>Africa</th>
<th>Eastern Africa (19 countries)</th>
<th>Middle Africa (9 countries)</th>
<th>Northern Africa (7 countries)</th>
<th>Southern Africa (5 countries)</th>
<th>Western Africa (17 countries)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Burundi</td>
<td>• Angola</td>
<td>• Algeria</td>
<td>• Botswana</td>
<td>• Benin</td>
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<td></td>
<td>• Comoros</td>
<td>• Cameroon</td>
<td>• Egypt</td>
<td>• Lesotho</td>
<td>• Burkina Faso</td>
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<td></td>
<td>• Djibouti</td>
<td>• Central African Republic</td>
<td>• Libyan Arab Jamahiriya</td>
<td>• Namibia</td>
<td>• Cape Verde</td>
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<td></td>
<td>• Eritrea</td>
<td>• Chad</td>
<td>• Morocco</td>
<td>• South Africa</td>
<td>• Côte d’Ivoire</td>
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<td></td>
<td>• Ethiopia</td>
<td>• Congo</td>
<td>• Sudan</td>
<td>• Swaziland</td>
<td>• Gambia</td>
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<td></td>
<td>• Kenya</td>
<td>• Democratic Republic of the Congo</td>
<td>• Tunisia</td>
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<td>• Ghana</td>
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<td></td>
<td>• Madagascar</td>
<td>• Equatorial Guinea</td>
<td>• Western Sahara</td>
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<td>• Guinea</td>
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<td>• Malawi</td>
<td>• Gabon</td>
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<td></td>
<td>• Guinea-Bissau</td>
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<td></td>
<td>• Mauritius¹</td>
<td>• São Tomé and Principe</td>
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<td>• Liberia</td>
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<td></td>
<td>• Mayotte</td>
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<td>• Mozambique</td>
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<td>• Réunion</td>
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<td>• Rwanda</td>
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<td>• Seychelles*</td>
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<td>• Somalia</td>
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<td>• Uganda</td>
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<td></td>
<td>• United Republic of Tanzania</td>
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<td></td>
<td>• Zambia</td>
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<td></td>
<td>• Zimbabwe</td>
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</tr>
</tbody>
</table>

¹ Including Agalega, Rodrigues, and Saint Brandon.
² Including Ascension, and Tristan da Cunha.
Appendix 8 (continued):

<table>
<thead>
<tr>
<th>Eastern Asia  (5 countries)</th>
<th>Central Asia$^3$  (5 countries)</th>
<th>South-eastern Asia  (11 countries)</th>
<th>Western Asia  (18 countries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• China</td>
<td>• Kazakhstan</td>
<td>• Brunei Darussalam</td>
<td>• Armenia</td>
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<td>o China, Hong Kong SAR</td>
<td>• Kyrgyzstan</td>
<td>• Cambodia</td>
<td>• Azerbaijan</td>
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<tr>
<td>o China, Macao Kong SAR</td>
<td>• Tajikistan</td>
<td>• Indonesia</td>
<td>• Bahrain</td>
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<tr>
<td>• Democratic</td>
<td>• Turkmenistan</td>
<td>• Lao People’s Democratic</td>
<td>• Cyprus</td>
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<tr>
<td>People’s Republic of</td>
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<tr>
<td>Korea</td>
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<td>• Japan</td>
<td>• Uzbekistan</td>
<td>• Republic Malaysia</td>
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<td>• Myanmar</td>
<td>• Iraq</td>
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<td>• Republic of Korea</td>
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<td>• Philippines</td>
<td>• Israel</td>
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<td></td>
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</tr>
<tr>
<td>Southern Asia$^3$  (9 countries)</td>
<td>• Afghanistan</td>
<td>• Singapore</td>
<td>• Jordan</td>
</tr>
<tr>
<td></td>
<td>• Bangladesh</td>
<td>• Thailand</td>
<td>• Kuwait</td>
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<td></td>
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<td>• Timor-Leste</td>
<td>• Lebanon</td>
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<td>• Viet Nam</td>
<td>Occuiped Palestinian</td>
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<td>Territories</td>
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<td>• Bhutan</td>
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<td></td>
<td>• India</td>
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<td>• Qatar</td>
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<td></td>
<td>• Iran (Islamic Republic of)</td>
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<td>• Saudi Arabia</td>
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<td>• Maldives</td>
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<td>• Syrian Arab Republic</td>
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<td>• Turkey</td>
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<tr>
<td></td>
<td>• Sri Lanka</td>
<td></td>
<td>• Yemen</td>
</tr>
</tbody>
</table>

$^3$ The regions Southern Asia and Central Asia are combined into South-Central Asia.
Appendix 8 (continued):

<table>
<thead>
<tr>
<th>Europe</th>
<th>Eastern Europe (10 countries)</th>
<th>Northern Europe (13 countries)</th>
<th>Southern Europe (16 countries)</th>
<th>Western Europe (9 countries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Belarus</td>
<td>• Channel Islands&lt;sup&gt;4&lt;/sup&gt;</td>
<td>• Albania</td>
<td>• Austria</td>
<td></td>
</tr>
<tr>
<td>• Bulgaria</td>
<td>• Denmark</td>
<td>• Andorra&lt;sup&gt;*&lt;/sup&gt;</td>
<td>• Belgium</td>
<td></td>
</tr>
<tr>
<td>• Czech Republic</td>
<td>• Estonia</td>
<td>• Bosnia and Herzegovina</td>
<td>• France</td>
<td></td>
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<tr>
<td>• Hungary</td>
<td>• Faeroe Islands&lt;sup&gt;*&lt;/sup&gt;</td>
<td></td>
<td>• Germany</td>
<td></td>
</tr>
<tr>
<td>• Poland</td>
<td>• Finland&lt;sup&gt;5&lt;/sup&gt;</td>
<td>• Croatia</td>
<td>• Liechtenstein&lt;sup&gt;*&lt;/sup&gt;</td>
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<tr>
<td>• Republic of Moldova</td>
<td>• Iceland</td>
<td>• Gibraltar&lt;sup&gt;*&lt;/sup&gt;</td>
<td>• Luxembourg</td>
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<tr>
<td>• Romania</td>
<td>• Ireland</td>
<td>• Greece</td>
<td>• Monaco&lt;sup&gt;*&lt;/sup&gt;</td>
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<tr>
<td>• Russian Federation</td>
<td>• Isle of Man&lt;sup&gt;*&lt;/sup&gt;</td>
<td>• Holy See&lt;sup&gt;6&lt;/sup&gt;</td>
<td>• Netherlands</td>
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<tr>
<td>• Slovakia</td>
<td>• Latvia</td>
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<td>• Switzerland</td>
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<td>• Ukraine</td>
<td>• Lithuania</td>
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<td></td>
<td>• Norway&lt;sup&gt;7&lt;/sup&gt;</td>
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<td></td>
<td>• Sweden</td>
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<tr>
<td></td>
<td>• United Kingdom of Great Britain and Northern Ireland&lt;sup&gt;8&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>• Malta</td>
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<td></td>
<td>• Montenegro</td>
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<td></td>
<td>• Portugal</td>
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<td></td>
<td>• San Marino&lt;sup&gt;*&lt;/sup&gt;</td>
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<td></td>
<td>• Serbia</td>
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<td>• Spain</td>
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<td></td>
<td>• The former Yugoslav Republic of Macedonia&lt;sup&gt;9&lt;/sup&gt;</td>
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<td></td>
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</tbody>
</table>

<sup>4</sup> Refers to Guernsey, and Jersey.
<sup>5</sup> Including Åland Islands.
<sup>6</sup> Refers to the Vatican City State.
<sup>7</sup> Including Svalbard and Jan Mayen Islands.
<sup>8</sup> Also referred to as United Kingdom.
<sup>9</sup> Also referred to as TFYR Macedonia.
**Appendix 8 (continued):**

### Latin America and the Caribbean

<table>
<thead>
<tr>
<th>Caribbean (24 countries)</th>
<th>Central America (8 countries)</th>
<th>South America (14 countries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anguilla*</td>
<td>Belize</td>
<td>Argentina</td>
</tr>
<tr>
<td>Antigua and Barbuda*</td>
<td>Costa Rica</td>
<td>Bolivia</td>
</tr>
<tr>
<td>Aruba</td>
<td>El Salvador</td>
<td>Bolivia</td>
</tr>
<tr>
<td>Bahamas</td>
<td>Guatemala</td>
<td>Brazil</td>
</tr>
<tr>
<td>Barbados</td>
<td>Honduras</td>
<td>Chile</td>
</tr>
<tr>
<td>British Virgin Islands*</td>
<td>Mexico</td>
<td>Colombia</td>
</tr>
<tr>
<td>Cayman Islands*</td>
<td>Nicaragua</td>
<td>Ecuador</td>
</tr>
<tr>
<td>Cuba</td>
<td>Panama</td>
<td>Falkland Islands (Malvinas)*</td>
</tr>
<tr>
<td>Dominica*</td>
<td></td>
<td>French Guiana</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td></td>
<td>Guyana</td>
</tr>
<tr>
<td>Grenada</td>
<td></td>
<td>Paraguay</td>
</tr>
<tr>
<td>Guadeloupe</td>
<td></td>
<td>Peru</td>
</tr>
<tr>
<td>Haiti</td>
<td></td>
<td>Suriname</td>
</tr>
<tr>
<td>Jamaica</td>
<td></td>
<td>Uruguay</td>
</tr>
<tr>
<td>Martinique</td>
<td></td>
<td>Venezuela (Bolivarian Rep. of)</td>
</tr>
<tr>
<td>Montserrat*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands Antilles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Puerto Rico</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saint Kitts and Nevis*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saint Lucia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saint Vincent and the</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grenadines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trinidad and Tobago</td>
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<td></td>
</tr>
<tr>
<td>Turks and Caicos Islands*</td>
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<tr>
<td>United States Virgin</td>
<td></td>
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<tr>
<td>Islands</td>
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</table>
Appendix 8 (continued):

<table>
<thead>
<tr>
<th>Northern American</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Bermuda*</td>
</tr>
<tr>
<td>• Canada</td>
</tr>
<tr>
<td>• Greenland*</td>
</tr>
<tr>
<td>• Saint Pierre and Miquelon*</td>
</tr>
<tr>
<td>• United States of America</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oceania</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Australia / New Zealand</strong> (2 countries)</th>
<th><strong>Melanesia</strong> (5 countries)</th>
<th><strong>Micronesia</strong> (5 countries)</th>
<th><strong>Polynesia</strong> (10 countries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Australia⁠↑¹⁰</td>
<td>• Fiji</td>
<td>• Guam</td>
<td>• American Samoa*</td>
</tr>
<tr>
<td>• New Zealand</td>
<td>• New Caledonia</td>
<td>• Kiribati*</td>
<td>• Cook Islands*</td>
</tr>
<tr>
<td></td>
<td>• Papua New Guinea</td>
<td>• Marshall Islands*</td>
<td>• French Polynesia</td>
</tr>
<tr>
<td></td>
<td>• Solomon Islands</td>
<td>• Micronesia (Federated States of)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Vanuatu</td>
<td>• Nauru*</td>
<td>• Niue*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Northern Mariana Islands*</td>
<td>• Pitcairn*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Palau*</td>
<td>• Samoa</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Tokelau*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Tonga</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Tuvalu*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Wallis and Futuna Islands*</td>
</tr>
</tbody>
</table>

¹⁰ Including Christmas Island, Cocos (Keeling) Islands, and Norfolk Island.

NOTE: Countries or areas with a population of less than 100,000 in 2009 are indicated by an asterisk (*). These countries or areas are included in the regional totals, but are not shown separately.
Appendix 9: The list of 109 global museums/ institutes in the 6 major areas of the world (as defined by the United Nations).

[This alphabetical list of museums/ institutes was reviewed by the 121 experts in 37 countries responded to the online survey].

**Africa** (4 museums/ 3 countries/ 4 experts)

<table>
<thead>
<tr>
<th>No.</th>
<th>Institute Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cape Town Science Centre [no.120]</td>
<td>South Africa</td>
</tr>
<tr>
<td>2</td>
<td>Ghana Planetarium Science Centre [no.100]</td>
<td>Ghana</td>
</tr>
<tr>
<td>3</td>
<td>Sci-Bono Discovery Centre [no.105]</td>
<td>South Africa</td>
</tr>
<tr>
<td>4</td>
<td>Tunis Science City [no.109]</td>
<td>Tunisia</td>
</tr>
</tbody>
</table>

**Asia** (12 museums/ 8 countries/ 15 experts)

<table>
<thead>
<tr>
<th>No.</th>
<th>Institute Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Birla Industrial &amp; Technological Museum [no.49]</td>
<td>India</td>
</tr>
<tr>
<td>2</td>
<td>Bloomfield Science Museum Jerusalem [no.56]</td>
<td>Israel</td>
</tr>
<tr>
<td>3</td>
<td>China Science and Technology Museum [no.50]</td>
<td>China</td>
</tr>
<tr>
<td>4</td>
<td>Communications Museum of Macao [no.58]</td>
<td>China</td>
</tr>
<tr>
<td>5</td>
<td>Feza Gürsey Bilim Merkezi (Feza Gürsey Science Centre) [no.26]</td>
<td>Turkey</td>
</tr>
<tr>
<td>6</td>
<td>Museum of science and technology in Islam [no.110]</td>
<td>Saudi Arabia</td>
</tr>
<tr>
<td>7</td>
<td>National Museum of Natural Science (Taichung) [no.18, no.22, no.23]</td>
<td>Taiwan (China)</td>
</tr>
<tr>
<td>8</td>
<td>National Science Museum [no.60]</td>
<td>Thailand</td>
</tr>
<tr>
<td>9</td>
<td>Nehru Science Centre [no.19]</td>
<td>India</td>
</tr>
<tr>
<td>10</td>
<td>Science Centre Singapore [no.38, no.40]</td>
<td>Singapore</td>
</tr>
<tr>
<td>11</td>
<td>Science City, Kolkata [no.9]</td>
<td>India</td>
</tr>
<tr>
<td>12</td>
<td>Science Discovery Center [no.36]</td>
<td>Philippines</td>
</tr>
</tbody>
</table>

**Europe** (34 museums/ 16 countries/ 34 experts)

<table>
<thead>
<tr>
<th>No.</th>
<th>Institute Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AHHAA Science Centre [no.44]</td>
<td>Estonia</td>
</tr>
<tr>
<td>2</td>
<td>Armagh Planetarium [no.1]</td>
<td>Northern Ireland (UK)</td>
</tr>
<tr>
<td>3</td>
<td>Belgrade's Science festival and Science Park Belgrade [no.42]</td>
<td>Serbia</td>
</tr>
<tr>
<td>4</td>
<td>Benjamin Franklin House [no.3]</td>
<td>UK</td>
</tr>
<tr>
<td>5</td>
<td>Center for the Promotion of Science [no.106]</td>
<td>Serbia</td>
</tr>
<tr>
<td>6</td>
<td>Centre for Life [no.2]</td>
<td>UK</td>
</tr>
<tr>
<td>7</td>
<td>Centre for Science Education [no.24]</td>
<td>Greece</td>
</tr>
<tr>
<td>8</td>
<td>Danish Museum of Energy [no.54]</td>
<td>Denmark</td>
</tr>
<tr>
<td>9</td>
<td>Deutsches Hygiene-Museum Dresden [no.16]</td>
<td>Germany</td>
</tr>
<tr>
<td>10</td>
<td>Enginuity [no.118]</td>
<td>UK</td>
</tr>
<tr>
<td>11</td>
<td>Eureka! The National Children’s Museum [no.25]</td>
<td>UK</td>
</tr>
</tbody>
</table>
### Appendix 9 (continued):

#### Europe [continued] (34 museums/ 16 countries/ 34 experts)

<table>
<thead>
<tr>
<th>No.</th>
<th>Museum / Institution / Location</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Experimentarium Science Center</td>
<td>Russia</td>
</tr>
<tr>
<td>13</td>
<td>Experimentarium</td>
<td>Denmark</td>
</tr>
<tr>
<td>14</td>
<td>Glasgow Science Centre</td>
<td>Scotland (UK)</td>
</tr>
<tr>
<td>15</td>
<td>Heureka, the Finnish Science Centre</td>
<td>Finland</td>
</tr>
<tr>
<td>16</td>
<td>iQpark</td>
<td>Czech Republic</td>
</tr>
<tr>
<td>17</td>
<td>Museo Galileo</td>
<td>Italy</td>
</tr>
<tr>
<td>18</td>
<td>Museu de Matemàtiques de Catalunya (MMACA)</td>
<td>Spain</td>
</tr>
<tr>
<td>19</td>
<td>National Space Centre</td>
<td>UK</td>
</tr>
<tr>
<td>20</td>
<td>Neanderthal Museum</td>
<td>Germany</td>
</tr>
<tr>
<td>21</td>
<td>Observatory Science Centre</td>
<td>UK</td>
</tr>
<tr>
<td>22</td>
<td>Oslo Science Center</td>
<td>Norway</td>
</tr>
<tr>
<td>23</td>
<td>Pilke Science Centre</td>
<td>Finland</td>
</tr>
<tr>
<td>24</td>
<td>Porthcurno Telegraph Museum</td>
<td>UK</td>
</tr>
<tr>
<td>25</td>
<td>Science Centre Delft (TUDelft)</td>
<td>Netherlands</td>
</tr>
<tr>
<td>26</td>
<td>Science Museum</td>
<td>UK</td>
</tr>
<tr>
<td>27</td>
<td>Serlachius Museums</td>
<td>Finland</td>
</tr>
<tr>
<td>28</td>
<td>Technoseum - Landesmuseum für Technik und Arbeit in Mannheim</td>
<td>Germany</td>
</tr>
<tr>
<td>29</td>
<td>Technotown</td>
<td>Italy</td>
</tr>
<tr>
<td>30</td>
<td>The Science Centre of Bragança (Centro Ciência Viva de Bragança)</td>
<td>Portugal</td>
</tr>
<tr>
<td>31</td>
<td>Thinktank Birmingham Science Museum</td>
<td>UK</td>
</tr>
<tr>
<td>32</td>
<td>Tyne and Wear Archives &amp; Museums</td>
<td>UK</td>
</tr>
<tr>
<td>33</td>
<td>Vsindasmijan [translates to ‘The Science workshop’]</td>
<td>Iceland</td>
</tr>
<tr>
<td>34</td>
<td>Wissens.Wert.Welt</td>
<td>Austria</td>
</tr>
</tbody>
</table>

#### Latin America and the Caribbean (11 museums/ 6 countries/ 12 experts)

<table>
<thead>
<tr>
<th>No.</th>
<th>Museum / Institution / Location</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Centro interactivo de Ciencias - La Punta</td>
<td>Argentina</td>
</tr>
<tr>
<td>2</td>
<td>Ciencia Viva</td>
<td>Uruguay</td>
</tr>
<tr>
<td>3</td>
<td>Espacio Ciencia LATU</td>
<td>Uruguay</td>
</tr>
<tr>
<td>4</td>
<td>Espaço Ciência (Museu Interativo de Ciência)</td>
<td>Brazil</td>
</tr>
<tr>
<td>5</td>
<td>Maloka</td>
<td>Colombia</td>
</tr>
<tr>
<td>6</td>
<td>Museo del Mar</td>
<td>Argentina</td>
</tr>
<tr>
<td>7</td>
<td>Museo Interactivo Mirador</td>
<td>Chile</td>
</tr>
<tr>
<td>8</td>
<td>Museo de Astronomia e Ciências Afins (MAST)</td>
<td>Brazil</td>
</tr>
<tr>
<td>9</td>
<td>Museu Exploratório de Ciências – Unicamp</td>
<td>Brazil</td>
</tr>
<tr>
<td>10</td>
<td>Parque Explora Medellín</td>
<td>Colombia</td>
</tr>
<tr>
<td>11</td>
<td>Planetario Alfa</td>
<td>Mexico</td>
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</tbody>
</table>
### Appendix 9 (continued):

**Northern American** (43 museums/ 2 countries/ 49 experts)

<table>
<thead>
<tr>
<th></th>
<th>Museum Name</th>
<th>Country</th>
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<tbody>
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<td>1</td>
<td>Arizona Science Center [no.13]</td>
<td>USA</td>
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<tr>
<td>2</td>
<td>Berkshire Museum [no.28]</td>
<td>USA</td>
</tr>
<tr>
<td>3</td>
<td>Canada Science and Technology Museum [no.10]</td>
<td>Canada</td>
</tr>
<tr>
<td>4</td>
<td>Cape fear museum of history and science [no.59]</td>
<td>USA</td>
</tr>
<tr>
<td>5</td>
<td>Clark Planetarium [no.63]</td>
<td>USA</td>
</tr>
<tr>
<td>6</td>
<td>Clay Center for the Arts &amp; Sciences [no.62]</td>
<td>USA</td>
</tr>
<tr>
<td>7</td>
<td>Columbia Memorial Space Center [no.72]</td>
<td>USA</td>
</tr>
<tr>
<td>8</td>
<td>Connecticut Science Center (CT Science Center) [no.64, no.80]</td>
<td>USA</td>
</tr>
<tr>
<td>9</td>
<td>COSI (Columbus, Ohio's dynamic Center of Science and Industry) [no.65]</td>
<td>USA</td>
</tr>
<tr>
<td>10</td>
<td>Creative Discovery Museum [no.69]</td>
<td>USA</td>
</tr>
<tr>
<td>11</td>
<td>Durango Discovery Museum [no.73]</td>
<td>USA</td>
</tr>
<tr>
<td>12</td>
<td>Evansville Museum [no.76]</td>
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</tr>
<tr>
<td>13</td>
<td>Explora [no.74, no.81]</td>
<td>USA</td>
</tr>
<tr>
<td>14</td>
<td>Exploratorium [no.35, no.57]</td>
<td>USA</td>
</tr>
<tr>
<td>15</td>
<td>Fleischmann Planetarium and Science Center [no.103]</td>
<td>USA</td>
</tr>
<tr>
<td>16</td>
<td>G Wiz - The Science Museum [no.83, no.108]</td>
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</tr>
<tr>
<td>17</td>
<td>Houston Museum of Natural Science [no.96]</td>
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<tr>
<td>18</td>
<td>Imiloa Astronomy Center of Hawaii [no.95]</td>
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<tr>
<td>19</td>
<td>Kalamazoo Aviation History Museum [no.12]</td>
<td>USA</td>
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<tr>
<td>20</td>
<td>Lakeview Museum of Arts &amp; Sciences [no.85]</td>
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<tr>
<td>21</td>
<td>Lawrence Hall of Science [no.88]</td>
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<tr>
<td>22</td>
<td>Miami Science Museum [no.99]</td>
<td>USA</td>
</tr>
<tr>
<td>23</td>
<td>MIT Museum (Massachusetts Institute of Technology Museum) [no.21]</td>
<td>USA</td>
</tr>
<tr>
<td>24</td>
<td>Mobius Science Center [no.98]</td>
<td>USA</td>
</tr>
<tr>
<td>25</td>
<td>Museum of Nature &amp; Science [no.94]</td>
<td>USA</td>
</tr>
<tr>
<td>26</td>
<td>Museum of Science &amp; Industry (MOSI) [no.86, no.87]</td>
<td>USA</td>
</tr>
<tr>
<td>27</td>
<td>Museum of Science, Boston [no.32]</td>
<td>USA</td>
</tr>
<tr>
<td>28</td>
<td>National Atomic Testing Museum [no.91]</td>
<td>USA</td>
</tr>
<tr>
<td>29</td>
<td>National Museum of Dentistry [no.93]</td>
<td>USA</td>
</tr>
<tr>
<td>30</td>
<td>National Parks and National Historic Sites (Parks Canada) [no.7]</td>
<td>Canada</td>
</tr>
<tr>
<td>31</td>
<td>New York Hall of Science [no.92]</td>
<td>USA</td>
</tr>
<tr>
<td>32</td>
<td>Ocean Star Offshore Drilling Rig Museum [no.90]</td>
<td>USA</td>
</tr>
<tr>
<td>33</td>
<td>Oregon Museum of Science and Industry (OMSI) [no.47, no.51]</td>
<td>USA</td>
</tr>
<tr>
<td>34</td>
<td>Petroleum Museum [no.89]</td>
<td>USA</td>
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</tbody>
</table>
**Appendix 9 (continued):**

<table>
<thead>
<tr>
<th></th>
<th>Name of the Museum</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>Science Museum of Minnesota [no.82]</td>
<td>USA</td>
</tr>
<tr>
<td>36</td>
<td>Sciencenter [no.97]</td>
<td>USA</td>
</tr>
<tr>
<td>37</td>
<td>Sci-Tech Discovery Center [no.78]</td>
<td>USA</td>
</tr>
<tr>
<td>38</td>
<td>SciTech Hands On Museum [no.67]</td>
<td>USA</td>
</tr>
<tr>
<td>39</td>
<td>Sony Wonder Technology Lab [no.84]</td>
<td>USA</td>
</tr>
<tr>
<td>40</td>
<td>TELUS Spark [no.8]</td>
<td>Canada</td>
</tr>
<tr>
<td>41</td>
<td>The Discovery Museums [no.77]</td>
<td>USA</td>
</tr>
<tr>
<td>42</td>
<td>The Franklin Institute [no.104]</td>
<td>USA</td>
</tr>
<tr>
<td>43</td>
<td>The Tech Museum [no.66]</td>
<td>USA</td>
</tr>
</tbody>
</table>

**Oceania (5 museums/ 2 countries/ 7 experts)**

<table>
<thead>
<tr>
<th></th>
<th>Name of the Museum</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Exscite centre - Waikato Museum [no.5, no. 11]</td>
<td>New Zealand</td>
</tr>
<tr>
<td>2</td>
<td>Grande Exhibitions [no. 55]</td>
<td>Australia</td>
</tr>
<tr>
<td>3</td>
<td>Monash Science Centre [no. 37]</td>
<td>Australia</td>
</tr>
<tr>
<td>4</td>
<td>Questacon--The National Science and Technology Centre [no.31]</td>
<td>Australia</td>
</tr>
<tr>
<td>5</td>
<td>Scitech [no. 30, no. 61]</td>
<td>Australia</td>
</tr>
</tbody>
</table>
Appendix 10: Online questionnaire in Case study 2

Cultural issues relating to the inclusive design of interactive science exhibits

Main page

Note that once you have clicked on the CONTINUE button at the bottom of each page you cannot return to review or amend that page.

All feedback received will be reported anonymously in the PhD thesis and any related publications.

My thanks in anticipation

Sumath Awsakulsutthi

If you would be prepared to discuss your feedback further, then please enter your contact details below.

1. Name: (Optional)

2. Name of the science museum or science centre:

3. Country:

4. Email:

5. Tel: (Optional)

General information

6. Sex:
   - Male
   - Female

7. Age range:
   - 19 and Under
   - 20-29
   - 30-39
   - 40-49
   - 50-59
   - 60-69
   - 70-79
   - >80
Appendix 10 (continued):

8. Position in the museum:
   - Director
   - Designer
   - Educator
   - Exhibitor
   - Researcher
   - Curator
   - Volunteer
   - Other (please specify):

The 10 dimensions of cultural issues of interactive science exhibits

The current understanding of relevant cultural issues is shown. The 10 areas of concern in relation to cultural issues have been identified:

- Physical skills
- Technologies issues
- Language issues
- Visual cultures
- Conceptual understanding
- Social issues
- Emotional values
- Prior age
- Disabled people
- Gender issues

The following photos originated from the National Science Museum in Thailand.

9. Physical skills:
For example, Thai people peel something by pushing a knife away from themselves. In the case of the Human power exhibit, an arrow indicates the correct direction to turn the dynamo. If it is difficult to turn, they will often turn the dynamo backwards even though the little train does move.

Do you believe that there are cultural issues affecting the use of interactive exhibits in regard to physical skills such as eyes, head, hands and body movement?

- Yes
- No

Please explain your answer, if one of your exhibits shows this issue.
Appendix 10 (continued):

10. Technology issues:
For example, switches need to be pushed down to "turn off" whereas in many countries pushing the switch down "turns on". Looking at the sun exhibit there is no information as to which way to operate the switch.

Do you believe there are cultural issues involved in the use and understanding of interactive exhibits demonstrating technologies?

- Yes
- No

Please explain your answer, if one of your exhibits shows this issue.

11. Language issues:
For example, the Thai description of the fluidised bed exhibit requires technical terms which are confusing in different languages.

Do you believe that there are cultural dimensions to the understanding of the language issues completely new to the visitors?

- Yes
- No

Please explain your answer, if one of your exhibits shows this issue.
Appendix 10 (continued):

12. Visual cultures:
For example, where there are concept cartoons which often tell a story with words. For the Vocal Vowels exhibit, the visitor may find the drawings confusing and even the sounds may not exist in the visitor’s language.

Do you believe there is cultural confusion in the visual cultures of interactive exhibits?

- Yes
- No

Please explain your answer, if one of your exhibits shows this issue.

13. Conceptual understanding:
For example, many children believe that light comes from the eyes to the object. This was an idea held by the ancients and in modern times reinforced by viewing comics and fairy tales such as Superman had laser eyes. The exhibit ‘Pepper’s Ghost’, where international visitors can confuse the concepts of light and vision.

Do you believe their are cultural issues in interactive exhibits where the emphasis is on understanding a concept?

- Yes
- No

Please explain your answer, if one of your exhibits shows this issue.
Appendix 10 (continued):

14. Social Issues:
For example, Thai people greet each other with a Wai (put the palms of the hands together). Western people and others shake hands. In the Real Image exhibit, the visitor is required to shake hands with their own reflected hand. Confusing for Thai visitors?

Do you believe that cultural issues can involve social behaviour?
- Yes
- No

Please explain your answer, if one of your exhibits shows this issue.

15. Emotional values:
For example, there are many symbols used to affect the emotions such as candles, music, fire works, colours in funerals and celebration parties. The magnetic forces exhibit visitors may be irritated, annoyed or happy to solve it.

Do you believe cultural differences influence emotional reactions?
- Yes
- No

Please explain your answer, if one of your exhibits shows this issue.
Appendix 10 (continued):

16. Age issues:
For example, England offers playgrounds in public parks for young children. It also discounts bus and railway tickets for old persons. Concerning the centrifuge exhibit, it may not be suitable for old visitors to sit down and rotate on it.

Do you believe that there are cultural concerns related to age issues?

- Yes
- No

Please explain your answer, if one of your exhibits shows this issue.

17. Gender issues:
Viewing the bicycle generator exhibit, most Thai girls wearing skirts would feel uncomfortable using it.

Do you believe that cultural issues involve gender issues?

- Yes
- No

Please explain your answer, if one of your exhibits shows this issue.
Appendix 10 (continued):

18. Disabled people:  
In the UK considerable effort is made to allow access by disabled people. Three steps have to be climbed to use the speaking dishes exhibit.

Do you believe that cultural considerations affect the use of interactive exhibits by disabled people?

- Yes
- No

Please explain your answer, if one of your exhibits shows this issue.

19. Do you believe these 10 dimensions of cultural issues can affect any of these exhibits by more than one dimension or not?

- Yes
- No

Please give your reason for answer.

20. Are there any more cultural issues that you believe should be considered?
Appendix 10 (continued):

21. Which one is the most important cultural issue in your museum?
   - Physical skills
   - Technologies issues
   - Language issues
   - Visual cultures
   - Conceptual understanding
   - Social issues
   - Emotional values
   - Prior age
   - Disabled people
   - Gender issues
   - Other (please specify):

22. Can you make any comments or further suggestions?

Please click ‘Continue’ to finish this survey.
Appendix 11: Survey question responses in Case study 2

These questions began in section 4 in the online questionnaire. The previous questions have recorded personal profiles of the museum experts. These experts replied with several comments which are reported below as follows. However, please note that a small number of the experts did not give an opinion for every question or empty answer as any ‘no comment’ which is not shown for saving the space of this appendix in the following information.

Section 4: The 10 dimensions of cultural issues of interactive science exhibits

9. Physical skills:
For example, Thai people peel something by pushing a knife away from themselves. In the case of the Human power exhibit, an arrow indicates the correct direction to turn the dynamo. If it is difficult to turn, they will often turn the dynamo backwards even though the little train does move. Do you believe that there are cultural issues affecting the use of interactive exhibits in regard to physical skills such as eyes, head, hands and body movement?

Please explain your answer, if one of your exhibits shows this issue.

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<th>Cultural regions</th>
<th>The experts comment</th>
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<tbody>
<tr>
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<tr>
<td></td>
<td>- Yes, (100. J.J.A., Director, Ghana Planetarium Science Centre, Ghana).</td>
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<td></td>
<td>- Yes, ‘I have seen this on a science of soccer exhibition where certain south African cultures have more experience with soccer skills and find the exhibits easier to use’ (105. M., Science Centre Manager, Sci-Bono Discovery Centre, South Africa).</td>
</tr>
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<td></td>
<td>- Yes, ‘Yes of course each nation behaves according the culture i.e. which they were brought up. The cultural factor is important in everyone perception’ (109. A.Z., Director, Tunis Science City, Tunisia).</td>
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<tr>
<td></td>
<td>- Yes, (120. A.L., Educator, Cape Town Science Centre, South Africa).</td>
</tr>
<tr>
<td>(2) Asia</td>
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<tr>
<td></td>
<td>- No, ‘There are no cultural barriers. If community habitual to a particular method, children try to follow the same. If they feel inconvenient in do so they try the other way’ (9. S.J.S., curator, Science City Kolkata, India).</td>
</tr>
</tbody>
</table>
|                   | - Yes, ‘In our energy ball exhibit a similar issue has been noticed. If no arrow is placed for rotation then the short path is chosen to pick
up the ball. But if you rotate anticlockwise, the trolley first hit the ball and then moves ahead. After that the wheel is rotated in opposite direction' (19. U.K., curator, Nehru Science Centre, India).

- Yes, 'It affects how the audiences play the exhibitions.' (22. C.L., researcher, National Museum of Natural Science in Taiwan, China).

- No, (23. K.C.C., volunteer, National Museum of Natural Science in Taiwan, China).

- Yes, 'In our culture, using a knife inwards is seen as bringing harm upon one’s self' (36. A.C.J., Director, Science Discovery Center, Philippines).

- No, (38. C.L.L., Evaluator, Science Centre Singapore, Singapore)

- No, (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).

- Yes, 'We have an exhibit called 'coded music' where a famous nursery rhyme is bar-coded on to a freely rotatable drum, which when turned clockwise reproduces the tune. Some people turn it in reverse manner but soon learns the right way too' (49. E.I., Director, Birla Industrial & Technological Museum: BITM, India).

- Yes, 'I think this is a kind of "action habit", our exhibits designed follow common habits, and forming good habits could reduce the risk to operator as well as the damage to machines' (50. Anonymous, Designer, China Science and Technology Museum, China).

- Yes, 'I think there are physical conventions related to how to use the exhibits. Generally if the exhibit is difficult to turn on one side, visitors may feel it is not the natural way to use the exhibit. In our water exhibit, the Antillia water wheel has similar problems' (56. D.A.P., Curator, Bloomfield Science Museum Jerusalem, Israel).

- No, (58. O., Curator, Communications Museum of Macao, China).

- Yes, 'Most Europeans pull the knife toward them, European kids tend to understand if you don’t follow the instruction it won’t work' (60. M.B., Science Show and Exhibit Design Consultant, National Science Museum, Thailand).

(3) Europe

- Yes, (1. C.J., Science Communicator, UK).

- Yes, 'Yes, I think that there are many culturally-specific gestures and motor skills' (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).

- Yes, 'I don't believe that the primary school students who use our interactive exhibits are affect by cultural issues in how they operate the exhibits, but I can imagine this can be a problem for others' (3.
- Yes, ‘Some interactive exhibits with a linear or sequential series of actions, might be laid out from left to right (or otherwise) to match the reading direction of text’ (4. D.S., Interpretation assistant, Glasgow Science Centre, UK).


- Yes, (15. H.H., director, Pike Science Centre, Finland).

- Yes, (16. S.D., assistant to the management board, Deutsches Hygiene Museum Dresden, Germany).

- Yes, (17. P.S., director, Serlachius Museums, Finland).


- No, (24. A.C., project manager, Centre for Science Education (CSE), Greece).

- No, ‘Visitor research has shown that users very rarely read instructions. The reverse turning may purely be out of curiosity, to see what happens if it’s used in a different way’ (25. Anonymous, Exhibit Manager, Eureka! The National Children’s Museum, UK).

- Yes, ‘We haven't expose our exhibits out of Spain; it means, into an homogeneous cultural area, so I can't answer your question but in hypothetical way’ (27. G., Sub-Director, mmaca Museu de Matemàtiques de Catalunya, Spain).

- No, (29, J.Š., Educator, iQpark, Czech Republic).

- Yes, ‘Already the direction the doors and windows are opening differs between the countries in Europe (and elsewhere)’ (33. P.J., Exhibition Manager, Heureka, the Finnish Science Centre, Finland).

- No, ‘I have found that as long as things are explained in a clear manner then there is rarely if ever a problem in this respect’ (34. S.A., Educator, National Space Centre, UK).

- Yes, ‘Only sometimes with understanding the correct direction to turn the handle for the static electricity machine demonstration which is why we usually do that particular one’ (39. D.K.M.G., Educator, Museo Galileo, Italy).

- No, ‘We are facing the same sort of problem here in Norway’ (41. J.A.A., Head of the Science Center, Oslo Science Center, Norway).

- No, ‘I made a version of this exhibit with bicycle, so that is one way to avoid the problem of direction’ (42. N.D., Coordinator of Science Exhibitions, Belgrade's Science festival and Science Park Belgrade, Serbia ).

- Yes, (43. M.B., Director of Media and Learning Center,
- Yes, (44. P.K., Director, AHHAA Science Centre, Estonia).
- No, (45. A.O., Director, Visindasmiðjan, Iceland).
- Yes, (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).
- Yes, 'There are cultural difference regarding the approach to the exhibits, particularly with adults but children seem to be able to get things to work one way or another. Women tend to hold back in arabic countries for example but the children do not' (53. S.P., Director, Observatory Science Centre, UK).
- No, 'Danish children will do the same - they do not always see the arrow - but just try out' (54. T., Curator, Danish Museum of Energy, Denmark).
- No, 'I think that everywhere would be the same, people are always trying to find easier way' (106. D.E., Head of Exhibitions and Publishing, Center for the Promotion of Science, Serbia).
- Yes, 'I believe that there are cultural issues affecting the use of interactive exhibits. But I am not completely certain that this example of the knife is a cultural one. I think it is an example of how we are conditioned by the use of certain technology. E.g. we are all conditioned to pedal our bicycles forward in a certain way and I believe this may have a bigger effect than the use of a knife, making it a technological issue rather than a cultural one. A more suitable cultural example may be the 'facial recognition' exhibit that asks the visitor to study a range of faces and decide if they are happy, angry, suprised etc. As westerners are more expressive, they have difficulty picking out the narrower range of expressiveness of Asian facial expressions' (111. C.L., Exhibitions Manager, Thinktank Birmingham Science Museum, UK).
- No, (112. I.F., Centro Ciência Viva de Bragança, Coordinator of explainers, Portugal).
- Yes, (113. N.V., Educator, Technotown, Italy).
- Yes, 'The inability to use your senses properly will be a bar to the use of the exhibit, unless it has been designed with this in mind'
(4) Middle East


(5) North America

- No, (7. Anonymous, interpretation specialist, National Parks and National Historic Sites, Canada).
- Yes, 'Maybe: the peeling shows something that looks awkward to me (we peel towards us). Interpretation of arrows and signs is also learned' (13. L.M., researcher, Arizona Science Center, USA).
- No, 'Depending on the culture or the education received, people often do what they think is easier, rather than what the exposition instructs as the correct way of performing an action' (14. Anonymous, educator, Planetario Alfa, Mexico).
- Yes, 'Holograms have an optimum viewing angle but positioning higher or lower necessarily privileges one group of visitors over another. Certain cultural norms may (or may not) encourage movement that allows the visitor to discover the best viewing angle' (21. D.D., curator, MIT Museum, USA).
- No, 'If the train moves when it’s turned in either direction, why is the turning direction important?’ (35. K.P. Director of Exhibit Services, Exploratorium, USA).
- Yes, (57. R.S., Executive Associate Director, Exploratorium, USA).
- No, 'I think, regardless of cultural issues, if something "appears" to not work the way a guest thinks it should work (or as fast as it
should in this case), the natural inclination is to try it another way’ (62. R.L.F., Director, Clay Center for the Arts & Sciences, USA).

- Yes, ‘Yes, but...I think it may be more simple than that for many instances of such behavior. Many people are used to turning certain things one direction. Many people don't seem to care, they just want to turn the crank. We see this all the time here. We have large easy to see arrows indicating direction of travel, but few people look at them, even though they are on the wheels they are turning’ (63. D.J., Educator, Clark Planetarium, USA).

- Yes, (64. H.H., Director, Connecticut Science Center, USA).

- No, ‘There my be cultural differences, but I have not witnessed any examples with our exhibitions’ (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).

- No, ‘This does not seem to be an issue with the populations we serve’ (66. L.C., Exhibitor, The Tech Museum, USA).

- Yes, ‘We have noticed that lower income/urban children don't know that exhibits have limitations physically, and tend to become rougher with the exhibits until they break. This is caused because the chaperones or the children do not take the time to read the properties of the exhibit, they just push buttons, turn cranks or whatever is needed to make it do something. Groups from more affluent areas take their time and expect the children to understand why they are doing what they are doing and with care’ (67. G.B. Curator, SciTech Hands On Museum, USA).

- No, (69. S., Exhibit Developer, Creative Discovery Museum, USA).

- Yes, (72. Anonymous, Educator, Columbia Memorial Space Center, USA).

- Yes, (73. H.S., Director, Durango Discovery Museum, USA).

- No, ‘Regardless of culture we all share the same physical body. For the most part we can all do the same things with it. Many things suggest ways in which they can be used like your hand crank petals. Some people will need help to use things [hence your arrow] although using it in the opposite direction provides a learning experience as well’ (74. E.M., Educator, Explora, USA).

- Yes, (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).


- Yes, ‘When the exhibits have themes, such the sports theme one we have now, people not exposed to the sport will have a harder time recognizing what to do’ (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).

- No, ‘I have found that if something does not work, they will keep
trying until it does within a certain amount of time. However, I believe there may be cultural issues in how long someone will try until they give up, or if they will even TRY something different (with the possibility of doing something wrong)' (80. Anonymous, Education Manager/Staff Scientist, Connecticut Science Center, USA).

- Yes, (81. Anonymous, Director, Explora, USA).

- Yes, 'There are cultural norms within society that impact how we each do things, whether it is peeling a fruit or interacting with a museum exhibition, culture impacts on our actions' (82. J.J.R., Director, Science Museum of Minnesota, USA).


- Yes, (84. Anonymous, Educator, Sony Wonder Technology Lab, USA).

- Yes, 'Just as you explained, but we would need an outside resource to identify such' (85. Anonymous, Educator, Lakeview Museum of Arts & Sciences, USA).

- No, 'Our exhibits in our Kids In Charge! area have very little explanation and we have found that people explore them a variety of ways' (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).


- Yes, (88. S.R., Researcher, Lawrence Hall of Science, USA).


- No, 'All cultures follow this pattern. All children FORCE handles and levers all directions regardless of instruction' (90. L.L., Director, Ocean Star Offshore Drilling Rig Museum: Offshore Energy Center, USA).


- Yes, (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).


- Yes, 'I believe there are cultural issues but I cannot define it, given that someone comes to a fork in the road is someone more apt to go to the right or the left?' (95. C.K.B., Associate Director, Imiloa
- Yes, (96. N.T., Director, Houston Museum of Natural Science: HMNS, USA).

- Yes, (97. Anonymous, Project Director of Exhibits and Programs, Sciencenter, USA).

- Yes, ‘While I believe that there are such issues, as you noted above, our regional population is sufficiently homogenous that we have not factored the phenomenon into design’ (98. C.M., CEO: Chief Executive Officer, Miami Science Museum, USA).

- Yes, ‘Experience has shown that some cultural groups prefer to interact as a couple and not as an individual - so we design to accommodate multiple users or shared use’ (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).

- Yes, (103. D.R., Director, Fleischmann Planetarium and Science Center, USA).

- Yes, ‘In the US, the large majority of people turn right when they enter an exhibition. This is not the case where people drive on the left side of the road’ (104. M.B., Researcher, The Franklin Institute, USA).

- Yes, ‘I have worked at two separate science centers and have seen issues like the one you describe above numerous times. Visitors in the United States have a tendency not to read signs or directions. When they walk up to an exhibit they interact with the exhibit based on what they think they should do with it, which stems from their life experiences and how they work things. When the exhibit does not do anything, then they will resort to trying other things until it works. Only as a last resort do they read the directions. Most will walk off before they read directions if the exhibit is not doing anything’ (108. J.H., Director of Education, GWIZ - The Science Museum, USA).

(6) Oceania

- No, ‘I believe clear design and functionality should cover any issues’ (5. S.S., curator, Exscite centre - Waikato Museum, New Zealand).


- No, (30. A.H., Director, Scitech, Australia).

- Yes, If showing play forward or rewind, need to use symbols similar to DVD players. Also, driving on left hand side of road can affect orientation’ (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

- Yes, ‘In Australia we approach exhibits and areas in general from left to right, but in places like the USA they will approach and
proceed through an exhibit from right to left” (37. C.W., Exhibitor, Monash Science Centre, Australia).


- Yes, (61. A.B., Director, Scitech, Australia).

(7) Russia

- No, ‘Nothing specific for Russia’ (119. I.K., Director, Experimentanium Science center, Russia).

(8) South America

- Yes, (68. A.C.P., Director, Espaço Ciência, Brazil).

- Yes, (70. F.A., Director, Centro interactivo de Ciencias - La Punta, Argentina).

- Yes, ‘We have an exhibit to show moment of inertia which is sometimes used as an amusement park attraction. Boys and girls tend to climb on it. There are more examples, like some bars that we propose to test the center of mass, and people prefer to hang of them’ (71. C.A., Educator, Parque Explora Medellín, Colombia).

- Yes, ‘I believe that it is always important to determine the target public and speak their language. We try to use informal language as much as possible’ (75. M.K., Evansville, Former Director, Brazil).

- No, ‘I do not believe any of our exhibitions shows such an issue. Our country is not multicultural, so this kind of things is hard to prove. Of course I could be wrong’ (79. V.P., Educator, Espacio Ciencia LATU, Uruguay).

- No, (101. M.H., Designer, Ciencia Viva, Uruguay).

- No, ‘Actually, I didn’t think about’ (102. M.E.V., Educator, Museu de Astronomia e Ciências Afins: MAST, Brazil).

- Yes, ‘Personal experiences depend on my basic skills, culture, experience and attitudes’ (107. E.H., Director, Maloka, Colombia).

- Yes, (114. P.D.S., Director, Museo del Mar, Argentina).

- Yes, ‘We believe that physical skills are extremely important but our exhibits for the most part are made thinking of the natural way we manipulate objects. For example, most exhibits have handles that work clock wise’ (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).

- Yes, (116. V.V., Educator, Museo Interactivo Mirador: MIM, Chile).
10. Technologies issues:
For example, switches need to be pushed down to "turn off" whereas in many countries pushing the switch down "turns on". Looking at the sun exhibit there is no information as to which way to operate the switch. Do you believe there are cultural issues involved in the use and understanding of interactive exhibits demonstrating technologies?

Please explain your answer, if one of your exhibits shows this issue.

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<td>Yes, (100. J.J.A., Director, Ghana Planetarium Science Centre, Ghana).</td>
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<td>‘Yes, I feel that museum often make exhibit choices based on the designers’ prior knowledge and experience. This is seen in an extreme form when visitors are presented with information on digital touch screen and many have never experience such screens. We have a digital touch screen on Astronomy in the centre’ (105. M., Science Centre Manager, Sci-Bono Discovery Centre, South Africa).</td>
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<td>‘Yes, the cultural factor is to be considered in our perception of science in the way we learn’ (109. A.Z., Director, Tunis Science City, Tunisia).</td>
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<tr>
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<td>No, (120. A.L., Educator, Cape Town Science Centre, South Africa).</td>
</tr>
<tr>
<td>(2) Asia</td>
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<td></td>
<td>Yes, ‘Children observe these simple things since their childhood. They try to follow the same things. Here they try to follow what their elders doing’ (9. S.J.S., curator, Science City Kolkata, India).</td>
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<td>Yes, (18. Y.J.S., curator, National Museum of Natural Science in Taiwan, China).</td>
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<td>Yes, 'If piano switches are used, this is certainly going to affect the result. Though after words it can be corrected. But for every new visitor or operating for the first time, it is true. But now we have overcome by using press switch. Still one of the exhibit dancing rings, switch was to be pressed to stop the illusion. People invariably missed the operation as in normal way switch is pressed to start the mechanism’ (19. U.K., curator, Nehru Science Centre, India).</td>
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<td>No, 'No! I don't think this should be called &quot;cultural&quot; ’(22. C.L., researcher, National Museum of Natural Science in Taiwan, China).</td>
</tr>
<tr>
<td></td>
<td>No, (23. K.C.C., volunteer, National Museum of Natural Science in Taiwan, China).</td>
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</tbody>
</table>
- No, (36. A.C.J., Director, Science Discovery Center, Philippines).

- No, 'This is not so much a cultural issue as it is a norm in most countries. Visitors will tend to experiment with things as well. If it doesn't work on way, they will just switch it the other way' (38. C.L.L., Evaluator, Science Centre Singapore, Singapore).

- Yes, 'In Singapore, it is push down to turn on. We hardly use a switch; we normally use a button to address this issue. Press once to turn on, press again to turn off' (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).

- No, 'I think 'interactivity' also implies providing multiplicity of options for the visitors in order that they are able to explore and discover ideas for themselves by logically linking results of their actions when using multiple choices to handle the exhibit. They will soon learn the best way to do things' (49. E.I., Director, Birla Industrial & Technological Museum: BITM, India).

- Yes, 'This is also a kind of "action habits", e.g. in a country with rules of driving on the right, we will not design a right driving car. Similarly, our exhibits will not be contrary to custom' (50. Anonymous, Designer, China Science and Technology Museum, China).

- Yes, 'Buttons in museums are always pressed, and sometimes several times even the display is already working. Sometimes buttons are used to stop the phenomenon. But you cannot rely on the visitors to know when to push the button. Reset mechanisms are some of the solutions in electronic displays' (56. D.A.P., Curator, Bloomfield Science Museum Jerusalem, Israel).

- Yes, (58. O., Curator, Communications Museum of Macao, China).

- Yes, 'In the world, there are 2 systems the American switch up for on English system switch down for on' (60. M.B., Science Show and Exhibit Design Consultant, National Science Museum, Thailand).

(3) Europe

- Yes, (1. C.J., Science Communicator, UK).

- Yes, 'There are cultural differences, but these can also be context-dependent. The best example (identified by Ben Gammon) was an old Science Museum exhibit ("Network 95") which featured telephone handsets to enable users at different stations to talk. Unfortunately, in a museum visitors expect a telephone handset to provide instructions or a commentary, so they always pick up the handset (engaging the line) so the exhibit cannot function' (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).

- Yes, 'Your example illustrates the problem clearly - being aware of such a trend or habit in the local population or your target audience is important when designing an exhibit. However I think the more
important thing is to make sure instructions, both written and verbal
from an educator if appropriate, are clear and easy to follow' (3.
S.W, educator, Benjamin Franklin House, UK).

- Yes, 'The controls of an interactive exhibit are often chosen to take
advantage of 'immediate apprehend ability' (a button is pushed; a
hand crank is turned etc.). When the controls are unfamiliar
(including other cultures), clear instructions are required' (4. D.S.,
Interpretation assistant, Glasgow Science Centre, UK).

- Yes, (6. Anonymous, educator, Porthcurno Telegraph Museum,
UK).

- Yes, (15. H.H., director, Pike Science Centre, Finland).

- Yes, (16. S.D., assistant to the management board, Deutsches
Hygiene Museum Dresden, Germany).

- Yes, (17. P.S., director, Serlachius Museums, Finland).

- Yes, 'But I think the people try again if it doesn't work out the way
there are used to do' (20. M.K., educator, Wissens.Wert.Welt,
Austria).

- No, (24. A.C., project manager, Centre for Science Education
(CSE), Greece).

- No, 'If the switch doesn't cause a reaction, it will be pressed again.
Switches, buttons are often pressed lots of times until something
happens. There is expectation that a switch/button will cause a
reaction of some kind' (25. Anonymous, Exhibit Manager, Eureka!
The National Children's Museum, UK).

- Yes, 'see answer 9' (27. G., Sub-Director, mmaca Museu de
Matemàtiques de Catalunya, Spain).

- No, (29, J.Š., Educator, iQpark, Czech Republic).

- Yes, (33. P.J., Exhibition Manager, Heureka, the Finnish Science
Centre, Finland).

- Yes, 'Potentially - I believe that any time you have a switch of any
description there should be some form of explanation of what one
should do' (34. S.A., Educator, National Space Centre, UK)


- No, 'I would think that the visitor will try to push the switch to try out
the effect' (41. J.A.A., Head of the Science Center, Oslo Science
Center, Norway).

- No, (42. N.D., Coordinator of Science Exhibitions, Belgrade's
Science festival and Science Park Belgrade, Serbia).

- Yes, (43. M.B., Director of Media and Learning Center,
Experimentarium, Denmark).

- Yes, (44. P.K., Director, AHAA Science Centre, Estonia).

- No, (45. A.O., Director, Visindasmíðjan, Iceland).


- Yes, ‘One example from our museum, which shows that culturally learned knowledge about technology determines the understanding of exhibits, concerns also a button. Usually visitors have to push down a button to activate an exhibit. In the case of an exhibit with an industrial robot, with whom you can play a game, there has to be a big red emergency switch. Sometimes visitors use this switch supposing that they can start the experiment by pushing the button, although the switch is labeled with “Emergency Switch”’ (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).

- Yes, ‘There can be but it always pays to watch how the visitors use the exhibit and make changes if needs be. Most people don't have trouble with hall/landing switches being up or down I suspect’ (53. S.P., Director, Observatory Science Centre, UK).

- No, ‘Most people will try one way or the other’ (54. T., Curator, Danish Museum of Energy, Denmark).

- No, ‘There are differences, but I don't believe that they are showing deeper cultural issues’ (106. D.E., Head of Exhibitions and Publishing, Center for the Promotion of Science, Serbia).

- Yes, (111. C.L., Exhibitions Manager, Thinktank Birmingham Science Museum, UK).

- No, (112. I.F., Centro Ciência Viva de Bragança, Coordinator of explainers, Portugal).

- Yes, (113. N.V., Educator, Technotown, Italy).


- Yes, ‘A number of the exhibits require users to turn them in a clockwise direction-an understanding of traditional clock faces rather than digital display is necessary for this’ (118. Anonymous, Educator, Enginuity - The Ironbridge Gorge Museum, UK).

- No, ‘When something doesn't work the first time, the visitor will usually try different ways of operating before giving up. Once they find the right way, they'll remember it' (121. M.S., Team Leader, Science Museum London, UK).
(4) Middle East


(5) North America

- No, (7. Anonymous, interpretation specialist, National Parks and National Historic Sites, Canada).


- Yes, 'Exactly because of what is cited above' (13. L.M., researcher, Arizona Science Center, USA).

- No, 'It is more of a custom issue rather than a cultural one' (14. Anonymous, educator, Planetario Alfa, Mexico).

- No, 'The true answer is "it depends" but almost all figure out what they are supposed to do' (21. D.D., curator, MIT Museum, USA).


- Yes, 'If the exhibit does not allow open ended exploration and the opportunity to do it incorrectly to see what happens, then users will derive much less from it' (35. K.P. Director of Exhibit Services, Exploratorium, USA).


- Yes, (57. R.S., Executive Associate Director, Exploratorium, USA).


- No, 'Basically same as last answer. I think it's just a guess' (62. R.L.F., Director, Clay Center for the Arts & Sciences, USA).

- Yes, 'In the US, there are many instances where switches can be on or off in either position in people's every-day lives. LEDs such as green for on and red to indicate off help visitors understand as do small labels on or near the switch. Again, anyone can be confused by this issue but culture can have an influence' (63. D.J., Educator,
Clark Planetarium, USA).

- Yes, (64. H.H., Director, Connecticut Science Center, USA).

- No, 'I believe that people in general will toggle a switch until they see a reaction. The best exhibits are intuitive and labels are referred to only when visitors cannot figure out an exhibit. But in this case, perhaps the type of switch could be changed to bring about a different result. In any case, if technology is a barrier, I think an explanatory label could be helpful. It is also important to note that technology should be incorporated when necessary for the experience, not just for the attraction of using the technology (such as using an iPad for example, when low-tech approach would be as effective)' (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).

- Yes, 'I would suggest this is not a "cultural" issue as much as a regional issue connected to prevailing technology' (66. L.C., Exhibitor, The Tech Museum, USA).

- Yes, 'There are exhibits that need very detailed instructions and if they are not in every language we serve they tend to not be used as much, thus not reaching people' (67. G.B. Curator, SciTech Hands On Museum, USA).

- No, 'Also, if you follow Universal Design principles there are probably better and more accessible options (dials, push buttons instead of switches) that would accommodate your objective better' (69. S., Exhibit Developer, Creative Discovery Museum, USA).

- Yes, (72. Anonymous, Educator, Columbia Memorial Space Center, USA).

- Yes, (73. H.S., Director, Durango Discovery Museum, USA).

- No, 'No and yes. If people are familiar with the technology, ie switches turn on and off electricity, they should be able to figure out which way it works. Again it is the familiarity which matters. We pedal bikes with our feet but your users adapted to using their hands to power the dynamo/generator. The cultural issue involved is the familiarity with using the technology. If you have not used a touch screen you may not know what to do with one' (74. E.M., Educator, Explora, USA).

- Yes, (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).


- Yes, 'Some people are not exposed to certain technologies that we take for granted. When an exhibit takes that concept for granted as well, the guest/user first has to learn how to use the machine before learning the science' (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).
- No, 'I have found that if something does not work, they will keep trying until it does within a certain amount of time. However, I believe there may be cultural issues in how long someone will try until they give up, or if they will even TRY something different (with the possibility of doing something wrong)' (80. Anonymous, Education Manager/Staff Scientist, Connecticut Science Center, USA).

- Yes, (81. Anonymous, Director, Explora, USA).

- Yes, ‘See my response above, some directions in exhibits can be universal, but if in one culture turning a switch up means off and in another it means on then those are cultural norms’ (82. J.J.R., Director, Science Museum of Minnesota, USA).


- Yes, ‘Different cultures have different levels of comfort with technology-specifically different interface designs. Some cultures/religions are less inclined to use more physical interactives... ’ (84. Anonymous, Educator, Sony Wonder Technology Lab, USA).


- No, 'Usually, people explore the exhibit using trial and error’ (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).

- No, 'Simple graphics should annotate every device so guests understand what pressing the switch does. 1 and 0 are international symbols for on and off’ (87. D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, (88. S.R., Researcher, Lawrence Hall of Science, USA).


- No, 'All cultures attempt to manipulate without reading instructions. They only read if they cannot get it to operate’ (90. L.L., Director, Ocean Star Offshore Drilling Rig Museum: Offshore Energy Center, USA).

- No, ‘There are only two ways the switch will go. They will try both until it works’ (91. Anonymous, Educator, National Atomic Testing Museum, USA).

- Yes, 'Even if there are labels, I still depend on the affordances of the buttons/handles/cranks/etc. to communicate what to do. So consciously and unconsciously, I'm depending on visitors' cultural expectations to hopefully lead them to the easiest way to use things. I haven't noticed a particular issue with my exhibits (though I didn't know that "down" meant "on", so now I'll be looking for that.) I try to
prototype just about everything, so maybe I’ve been able to avoid many misconceptions by changing the exhibit in response to visitor feedback. Many of the things I create call for non-standard ways of interacting with the exhibits (more than just reading and button-pushing). So I prototype a lot in order to understand how to make the exhibit usage obvious and compelling for a wide variety of people. But I’m sure I get it wrong sometimes - especially when I’m depending on a cultural reference to communicate a piece of the content. An example: We made a computer interactive that resembled an Etch-a-Sketch which was an iconic mechanical drawing toy invented in the 1950’s. Children could manipulate two knobs that controlled the motion of a stylus that scratched a continuous line on a screen -- one knob controlled the right-and-left motion, one controlled the up-and-down motion. For our computer interactive, we needed visitors to separately control the x- and y-axes. So, we made our computer interactive look like an Etch-a-Sketch, drawing on the cultural expectation that the knobs controlled right-and-left and up-and-down. It was really useful to have that cultural icon to refer to, and many visitors understood what the controls did even without reading the labels. BUT, since that only worked for people who already knew what an Etch-a-Sketch was, we needed to have labels on the knobs. Luckily, we had prototyped the interactive, so we knew the labels would still be necessary’ (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).

- No, (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).
- No, ‘Given the previous two examples, it appears the issue is exhibit design. For example, turn the switch from side to side rather than up and down’ (96. N.T., Director, Houston Museum of Natural Science: HMNS, USA).
- Yes, (97. Anonymous, Project Director of Exhibits and Programs, Sciencenter, USA).
- Yes, ‘In this case we would consider it a non-factor. The purpose of a science center exhibit is to get people to interact with it - not merely follow directions. In our case we intentionally have minimal signage and instruction so that people need to play with switches, knobs, buttons etc. to produce effects’ (98. C.M., CEO: Chief Executive Officer, Miami Science Museum, USA).
- Yes, ‘yes - if the switch or device is counterintuitive then this step is a hurdle to focusing on the intended content’ (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).
- Yes, (103. D.R., Director, Fleischmann Planetarium and Science
<table>
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<tr>
<th>Region</th>
<th>Response</th>
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<tbody>
<tr>
<td>Oceania</td>
<td>- Yes, ‘Again clear design combined with exploration by children should negate any possible issues’ (5. S.S., curator, Exscite centre - Waikato Museum, New Zealand).</td>
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<td>- Yes, (30. A.H., Director, Scitech, Australia).</td>
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<td>- Yes, ‘Switches as described’ (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).</td>
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<td>- Yes, ‘In Timor-Leste an exhibit using computers assumed prior knowledge of computer use, which was not always the case. Many children had seen, but not ever handled a computer or computer mouse’ (37. C.W., Exhibitor, Monash Science Centre, Australia).</td>
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<td>- Yes, (61. A.B., Director, Scitech, Australia).</td>
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<td>Russia</td>
<td>- No, (119. I.K., Director, Experimentanium Science center, Russia).</td>
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<td>South America</td>
<td>- Yes, (68. A.C.P., Director, Espaço Ciência, Brazil).</td>
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<td>- Yes, (70. F.A., Director, Centro interactivo de Ciencias - La Punta, Argentina).</td>
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<td>- Yes, ‘I think there are more due to age issues. It’s difficult for older people to understand some of our exhibits’ (71. C.A., Educator, Parque Explora Medellín, Colombia).</td>
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<td>- No, ‘These simple issues can be easily solved by trial and error’ (75. M.K., Evansville, Former Director, Brazil).</td>
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<td>- No, ‘It is common here to have ceiling lights with two switches located in opposite places in a room, so we don not identify up en down with on and off’ (79. V.P., Educator, Espacio Ciencia LATU, Uruguay).</td>
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|          | - No, ‘People will try making it work somehow. The younger they
are, the less they will relay in "standards"' (101. M.H., Designer, Ciencia Viva, Uruguay).

- Yes, 'Not exactly cultural but the lack of familiarity with the apparatus as a mechanical instrument to give you some information' (102. M.E.V., Educator, Museu de Astronomia e Ciências Afins: MAST, Brazil).

- Yes, 'The same answer as in the question # 9' (107. E.H., Director, Maloka, Colombia).

- Yes, (114. P.D.S., Director, Museo del Mar, Argentina).

- Yes, 'We consider that the person first instruction is always cultural, the way he or she first learned how to manipulate the technological object, but one it doesn't work the person tries a different method' (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).

- Yes, 'I think in my country have the same issue and we will have the same problem with a exhibition' (116. V.V., Educator, Museo Interactivo Mirador: MIM, Chile).

11. Language issues:
For example, the Thai description of the fluidised bed exhibit requires technical terms which one confusing in different languages. Do you believe that there are cultural dimensions to the understanding of the language issues completely new to the visitors?

Please explain your answer, if one of your exhibits shows this issue.

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<thead>
<tr>
<th>Cultural regions</th>
<th>The experts comment</th>
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<tbody>
<tr>
<td>(1) Africa</td>
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<td>- Yes, (100. J.J.A., Director, Ghana Planetarium Science Centre, Ghana).</td>
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<td>- 'Yes, Signage and language is incredibly important when considering the varied background of visitors in science centres. All to often the language used is too technical and is sometimes even translated incorrectly. Besides the technical terms that are used, even the grammatical formulation of sentences can cause problems in visitors understanding of the concepts. I think that this is evident of numerous different exhibits that I have seen' (105. M., Science Centre Manager, Sci-Bono Discovery Centre, South Africa).</td>
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<td>- 'Yes, There certainly cultural dimension to the understanding of the language issues' (109. A.Z., Director, Tunis Science City, Tunisia).</td>
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<td>- Yes, (120. A.L., Educator, Cape Town Science Centre, South Africa).</td>
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Asia

- Yes, 'Language is one thing which has to be understood completely. If somebody understand half of the language and if he finds similar words in his language, there is a change of misunderstanding the entire concept' (9. S.J.S., curator, Science City Kolkata, India).


- Yes, 'Most of our exhibits are having bilingual labels. One in English and other as Hindi or local language. Still Centres attracting lot of tourist visitors receive complaints about the language of communication. English is understood by only few people' (19. U.K., curator, Nehru Science Centre, India).

- No, 'It's a language issue rather than a culture issue. It dependents on the quality of translation between languages' (22. C.L., researcher, National Museum of Natural Science in Taiwan, China).

- No, (23. K.C.C., volunteer, National Museum of Natural Science in Taiwan, China).

- No, (36. A.C.J., Director, Science Discovery Center, Philippines).

- Yes, (38. C.L.L., Evaluator, Science Centre Singapore, Singapore)

- No, 'In Singapore, our main panels are in English' (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).

- Yes, 'Ours is a vastly multi-lingual and multi-cultural society and we put both the English and the local versions of the terminologies. But even then, we need to have explainers to overcome cultural & linguistic barriers' (49. E.I., Director, Birla Industrial & Technological Museum: BITM, India).

- Yes, 'If audience is familiar with the theory or technology, the description will not affect much. But if audience need learn the knowledge from the exhibit, they will need combine description and operation to understand completely, so that the text is a key aspect to assist them. (under the situation that without guide to explain everything)' (50. Anonymous, Designer, China Science and Technology Museum, China).

- Yes, 'Mainly if there are different uses of colloquial terms and science terms specific to one language that can confuse visitors' (56. D.A.P., Curator, Bloomfield Science Museum Jerusalem, Israel).

- Yes, (58. O., Curator, Communications Museum of Macao, China).

- Yes, 'Even if a phenomenon can be explained in a language often a translation from another language is a disaster' (60. M.B., Science Show and Exhibit Design Consultant, National Science Museum,
(3) Europe

- Yes, (1. C.J., Science Communicator, UK).

- Yes, 'Literal translations are rarely satisfactory, as anyone who tours exhibitions internationally realises very quickly' (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).

- Yes, 'Avoiding slang is important when writing explanatory text and instructions, as is the case with our interactive blood circulation game which requires a series of tubes to be connected in the correct alignment. We use visual rather than written instructions to make the exhibit easy to use' (3. S.W, educator, Benjamin Franklin House, UK).


- Yes, 'Not in the museum context, but as a teacher of science previously, I know that the use of the word 'table' in the context of recording results is very confusing for someone with limited English. I also know that one cannot make assumptions about familiarity with the globe and relative positions on it, even with 15 year old children, as they may never have seen one or had the chance to make sense of one' (6. Anonymous, educator, Porthcurno Telegraph Museum, UK).

- Yes, (15. H.H., director, Pike Science Centre, Finland).

- Yes, (16. S.D., assistant to the management board, Deutsches Hygiene Museum Dresden, Germany).

- Yes, (17. P.S., director, Serlachius Museums, Finland).


- Yes, 'Interactive exhibits should be designed in a way requiring minimum explanation. Where necessary we have translated information in English and French' (24. A.C., project manager, Centre for Science Education (CSE), Greece).


- Yes, 'see answer 9’ (27. G., Sub-Director, mmaca Museu de Matemàtiques de Catalunya, Spain).

- Yes, 'I think it can be difficult for people to understand “science” language. But once translated into English, it should be obvious, what somebody means' (29, J.Š., Educator, iQpark, Czech Republic).

- No, (33. P.J., Exhibition Manager, Heureka, the Finnish Science
- Yes, 'However, I think that these can be difficult to overcome since different languages have their own complexities for technical words, however I do not necessarily think that oversimplifying everything is particularly effective as this then impacts your primary, native speaking audience' (34. S.A., Educator, National Space Centre, UK).

- Yes, 'Sometimes like with the word ESCAPE MECHANISM when learning how energy is used to keep time' (39. D.K.M.G., Educator, Museo Galileo, Italy).

- Yes, (41. J.A.A., Head of the Science Center, Oslo Science Center, Norway).

- Yes, (42. N.D., Coordinator of Science Exhibitions, Belgrade's Science festival and Science Park Belgrade, Serbia).

- Yes, (43. M.B., Director of Media and Learning Center, Experimentarium, Denmark).

- Yes, (44. P.K., Director, AHHAA Science Centre, Estonia).

- Yes, (45. A.O., Director, Visindasmíðjan, Iceland).

- Yes, 'All our exhibits have a highly technical content, our videos have different levels of abstract language at each exhibit' (46. L.H., Educator, Science Centre Delft: TUDelft, Netherlands).


- Yes, 'I think there are not only cultural dimensions of the understanding of language, e.g. technical terms, between different societies and cultures, but also between different groups of one society depending on the social, educational and professional background or the age of the person. An engineer or a mechanic for example has no difficulties to understand technical terms, whereas someone who hasn't any technical training doesn't know them. We therefore use different levels of difficulty of language in our texts: One simple instruction in everyday language (often with some drawings), how to start the exhibit ("What is to do?") a short and simple explanation of the scientific phenomenon, which can be observed ("What happens here?") and a longer and more complex scientific or technical explanation ("A closer look") (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).

- Yes, 'Yes but we always work with the people receiving the exhibit, it is bad practice not to' (53. S.P., Director, Observatory Science Centre, UK).

- Yes, 'Confusing technical terms may cause trouble' (54. T., Curator, Danish Museum of Energy, Denmark).

- Yes, 'I think that language as a principal human communication
tool has a complex and important cultural system which can be related to your point of interest' (106. D.E., Head of Exhibitions and Publishing, Center for the Promotion of Science, Serbia).

- No, 'I believe that this transcends all languages. It is the use of jargon in any language that is difficult for the layman to comprehend when they come across it the first time as they do not have a concrete definition for themselves that poses a barrier. Computer and internet are examples of contemporary words that have gained mainstream usage very quickly because people connect to them' (111. C.L., Exhibitions Manager, Thinktank Birmingham Science Museum, UK).

- Yes, (112. I.F., Centro Ciência Viva de Bragança, Coordinator of explainers, Portugal).

- Yes, (113. N.V., Educator, Technotown, Italy).


- Yes, 'Languages will be a barrier if you rely solely on text. If you include well thought out graphics then you'll probably overcome many of these problems' (121. M.S., Team Leader, Science Museum London, UK).

(4) Middle East


(5) North America


- Yes, 'Good design and thought avoids this - it is the hazard of jargon use and specialized language. Paying attention to your audience (or audiences) will preclude this from happening' (8. D.H., director, TELUS Spark, Canada).

- Yes, 'As a national institution, our museum must write all exhibition text both in English and French. Technical terms in English seem more accessible to our English visitors than French technical terms to our French speaking visitors. We typically text out the terminology used in our exhibitions in both English and French to ensure that the Museum is using accessible language' (10. A.J., educator, Canada Science and Technology Museum, Canada).

- Yes, 'Signage can be confusing even within one culture!' (13. L.M., researcher, Arizona Science Center, USA).

- No, 'It is more in the level of education where people might know or not the technical words. However someone not familiar with the language will have issues understanding those technical terms regardless of the education level they hold' (14. Anonymous, educator, Planetario Alfa, Mexico).

- Yes, 'But "so what"? That's the joy and fascination of visiting a museum in a different culture. You learn how the world works from a new perspective' (21. D.D., curator, MIT Museum, USA).

- Yes, 'There would be language issues in any language; even between people who use the same language' (28. Anonymous, Exhibitor, Berkshire museum, USA).


- Yes, 'Translating directly from one language to another may change or omit important context' (35. K.P. Director of Exhibit Services, Exploratorium, USA).


- Yes, (57. R.S., Executive Associate Director, Exploratorium, USA).


- Yes, 'I think this is a possibility here. Translations are key and very tricky at times' (62. R.L.F., Director, Clay Center for the Arts & Sciences, USA).

- No, 'There may certainly be a language barrier, but I don't think that it will be "completely new" to most visitors. The fewer the words, the more people usually read the text' (63. D.J., Educator, Clark Planetarium, USA).

- Yes, (64. H.H., Director, Connecticut Science Center, USA).

- Yes, 'Technical language is difficult to communicate in any language. We try to keep technical language to a minimum--and that language should be accessible to visitors of age 10 and up (minimum), but all of our exhibits are in English (and most visitors speak English)' (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).

- Yes, 'Yes, our signage is in English and Spanish and often the translations are inexact' (66. L.C., Exhibitor, The Tech Museum,
- Yes, ‘Same answer as in the previous question, because we are such a diverse area, we cannot possibly put the exhibits in every language to accommodate every person’ (67. G.B. Curator, SciTech Hands On Museum, USA).

- Yes, ‘Language issues are not always cultural though. They could arise any time you introduce new terms and depends on the tone and length of your signage’ (69. S., Exhibit Developer, Creative Discovery Museum, USA).

- Yes, (72. Anonymous, Educator, Columbia Memorial Space Center, USA).

- Yes, (73. H.S., Director, Durango Discovery Museum, USA).

- Yes, ‘I believe that people can and should be given the opportunity to discover the phenomenon with which they are playing/experimenting. The scientific vocabulary is secondary at best. I think it is better to think about what people can discover at an exhibit instead of what you want them to discover. Without pushing specific discoveries you can reduce the dependence on technical terms that may be confusing or intimidating’ (74. E.M., Educator, Explora, USA).

- Yes, (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).


- Yes, ‘Science vocabulary should be explained in simpler terms, regardless of the language’ (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).

- Yes, (80. Anonymous, Education Manager/Staff Scientist, Connecticut Science Center, USA).

- Yes, ‘We use imagery at exhibits as much as possible to avoid the confusion’ (81. Anonymous, Director, Explora, USA).

- Yes, ‘This question doesn't make sense to me’ (82. J.J.R., Director, Science Museum of Minnesota, USA).


- Yes, (84. Anonymous, Educator, Sony Wonder Technology Lab, USA).


- No, ‘Only if your exhibit designers find it necessary to explain in complicated detail. Having people explore with Try this..and what
happened? or What happens when.... What is it that really is important to take away from the exhibit? The content or the exploration? Depends on your institution's mission' (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, 'Technical terms and science explanations can be confusing and unfamiliar to all people, and can be more so to someone who has a language barrier' (87. D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, (88. S.R., Researcher, Lawrence Hall of Science, USA).


- Yes, 'Oil and gas industry has particular language difficult to translate to our foreign visitors' (90. L.L., Director, Ocean Star Offshore Drilling Rig Museum: Offshore Energy Center, USA).

- Yes, 'Yes, many of the exhibits in our nuclear museum are very technical, and must be difficult to those not fluent in English. They are difficult to those who do speak English and are unfamiliar with the technical terminology' (91. Anonymous, Educator, National Atomic Testing Museum, USA).

- Yes, 'Certainly getting good translations of exhibit labels can really help people use the exhibit. But as you point out, technical terms could be alienating and confusing even when they're in your native language. I always try to write labels for learners instead of for experts. It's hard to do, but usually not impossible' (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).


- Yes, 'We are a bilingual Science Center, everything is explained in Hawaiian and then English, it makes for longer text panels but we felt that it was important to have the host culture first' (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).

- Yes, 'It may not be a foreign language issue but rather an new vocabulary issue, but often words are a barrier to visitors' (96. N.T., Director, Houston Museum of Natural Science: HMNS, USA).

- Yes, (97. Anonymous, Project Director of Exhibits and Programs, Sciencenter, USA).

- No, 'I am clear that I don't fully understand the question and it seems as if you are overt complicating things. Good picture based instructions and enticing exhibits will make all of these cultural carries and limitations non-issues' (98. C.M., CEO: Chief Executive Officer, Miami Science Museum, USA).
- Yes, 'We develop exhibitions with bilingual interpretation in mind from them very beginning of development. To achieve comprehensible text we don't write anything in one language we can't communicate as manageably in the other' (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).

- Yes, (103. D.R., Director, Fleischmann Planetarium and Science Center, USA).

- Yes, 'We would probably not say "fluidized bed". Language issues are crucial in instructional text. We always test this kind of text on visitors before building a device' (104. M.B., Researcher, The Franklin Institute, USA).


(6) Oceania

- Yes, 'We often print our signs in both recognised New Zealand languages, English and Maori. It is important for any audience to break down the language so that all visitors can understand' (5. S.S., curator, Exscite centre -Waikato Museum, New Zealand).


- Yes, (30. A.H., Director, Scitech, Australia).

- No, (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

- Yes, 'Some languages do not have concise descriptive words for technological issues e.g. when describing rocks in a geology exhibition the wording was very long when explaining a type of fossil bearing rock as the local language did not have a specific word for it' (37. C.W., Exhibitor, Monash Science Centre, Australia).

- Yes, 'we often need to adapt understanding level into other languages as the words or relevance do not make sense' (55. Anonymous, Museum Supplier, Grande Exhibitions, Australia).

- Yes, (61. A.B., Director, Scitech, Australia).

(7) Russia

- No, (119. I.K., Director, Experimentanium Science center, Russia).

(8) South America

- Yes, (68. A.C.P., Director, Espaço Ciência, Brazil).

- Yes, (70. F.A., Director, Centro interactivo de Ciencias - La Punta, Argentina).

- Yes, 'Our work consists in trying not to include technical terms. But not always is possible' (71. C.A., Educator, Parque Explora Medellín, Colombia).
- Yes, ‘This is an intrinsic part of the issues raised by Science centers, trying to explain complex phenomena. A glossary always is useful’ (75. M.K., Evansville, Former Director, Brazil).

- Yes, ‘I do not know if it is cultural or educational. We work with guides and they try to explain the exhibits to our visitors with a language according to their ages. But sometimes you can observe that some of them actually don’t understand clearly and other people are really fast getting the right information’ (79. V.P., Educator, Espacio Ciencia LATU, Uruguay).

- Yes, ‘This issue is present in almost every exhibit’ (101. M.H., Designer, Ciencia Viva, Uruguay).

- Yes, ‘Yes, since language is something particular of a group even in different neighbourhoods in the same city’ (102. M.E.V., Educator, Museu de Astronomia e Ciências Afins: MAST, Brazil).

- Yes, ‘Of course. The same answer as #9’ (107. E.H., Director, Maloka, Colombia).

- Yes, (114. P.D.S., Director, Museo del Mar, Argentina).

- Yes, ‘Because technical terms are very common in every language, not the colloquial terms, in this case you can find multiple uses for the same word depending where you are from’ (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).

- Yes, (116. V.V., Educator, Museo Interactivo Mirador: MIM, Chile).

12. Visual cultures:
For example, where there are concept cartoons which often tell a story with words. For the Vocal Vowels exhibit, the visitor may find the drawings confusing and even the sounds may not exist in the visitor's language. Do you believe there is cultural confusion in the visual cultures of interactive exhibits?

Please explain your answer, if one of your exhibits shows this issue.

<table>
<thead>
<tr>
<th>Cultural regions</th>
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<tr>
<td>(1) Africa</td>
<td></td>
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<td></td>
<td>- Yes, (100. J.J.A., Director, Ghana Planetarium Science Centre, Ghana).</td>
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<td>- Yes, ‘When using cartoons on exhibits, we need to be very careful. The visitor needs to be able to identify with the character or the effectiveness is lost. I once experienced a set of exhibits which were imported from another country to South Africa and some of the images where even offensive to the South Africans who used the exhibition’ (105. M., Science Centre Manager, Sci-Bono Discovery</td>
</tr>
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</table>

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Centre, South Africa).

- Yes, 'Yes of course' (109. A.Z., Director, Tunis Science City, Tunisia).

- No, (120. A.L., Educator, Cape Town Science Centre, South Africa).

(2) Asia

- Yes, 'Sometimes visuals lead to different meanings. There should be appropriate write-ups to explain exactly what we mean to tell' (9. S.J.S., curator, Science City Kolkata, India).


- Yes, ‘When visitors see labels and instructions in other language, they go away. Also written like a book turns the visitors away. If shown in an illustrated way, it is more acceptable, e.g. in test your endurance exhibit in human and machine gallery, it was written that they should hold the pipes and go up and down for some time. Rarely people saw that and acted. Then we placed two circular bands in contrast colours, it worked well’ (19. U.K., curator, Nehru Science Centre, India).

- Yes, (22. C.L., researcher, National Museum of Natural Science in Taiwan, China).

- No, (23. K.C.C., volunteer, National Museum of Natural Science in Taiwan, China).

- No, (36. A.C.J., Director, Science Discovery Center, Philippines).

- No, (38. C.L.L., Evaluator, Science Centre Singapore, Singapore).

- Yes, (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).

- Yes, ‘We therefore use those which the majority would be able to relate to’ (49. E.I., Director, Birla Industrial & Technological Museum: BITM, India).

- Yes, 'Indeed, there is cultural confusion, but the function of the Science and Technology Museum is to expand the scope of knowledge and answer questions, if the sounds do not exist in another language, we could learn how they say it and reduce blind zone' (50. Anonymous, Designer, China Science and Technology Museum, China).

- No, ‘I think there are good and bad designs that have to be tested with visitors’ (56. D.A.P., Curator, Bloomfield Science Museum Jerusalem, Israel).
- No, (58. O., Curator, Communications Museum of Macao, China).

- Yes, 'The plasma ball explanation needs prior knowledge for understanding. Speech sounds vary tremendously in languages, in some there are few vowels' (60. M.B., Science Show and Exhibit Design Consultant, National Science Museum, Thailand).

(3) Europe

- Yes, 'We have no exhibits showing this issue but I have encountered oddities such as visitors believing images of real space and astronomical objects were artist's impressions and visitors believing small scale models of spacecraft were actual size' (1. C.J., Science Communicator, UK).

- No, 'Most interactive exhibits are used by a single nationality as most are located in the smaller, regional science centres. As long as each venue tailors the exhibits to its own audience this doesn't arise. Exceptions may be in bilingual countries, like Wales, but your vowel sounds example originates from Techniquest in Cardiff' (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).

- Yes, 'I'm sure there will be, though we have not experienced this problem with our exhibits' (3. S.W, educator, Benjamin Franklin House, UK).


- Yes, (15. H.H., director, Pike Science Centre, Finland).

- Yes, (16. S.D., assistant to the management board, Deutsches Hygiene Museum Dresden, Germany).

- Yes, (17. P.S., director, Serlachius Museums, Finland).


- No, (24. A.C., project manager, Centre for Science Education (CSE), Greece).

- No, 'Correct interpretation that is sympathetic to a range of users should help combat this problem. Not all exhibits can be relative to all cultures, but this doesn't mean the outcomes can't be understood through careful interpretation' (25. Anonymous, Exhibit Manager, Eureka! The National Children's Museum, UK).

- Yes, 'see answer 9' (27. G., Sub-Director, mmaca Museu de Matemàtiques de Catalunya, Spain).

- No, (29, J.Š., Educator, iQpark, Czech Republic).

- Yes, 'Already the signs for 'right' and 'wrong' differ between cultures' (33. P.J., Exhibition Manager, Heureka, the Finnish Science Centre, Finland).

- No, 'I think that the science behind the exhibit makes sense even if the vowels themselves do not' (34. S.A., Educator, National Space Centre, UK)

- Yes, 'Yes because the letter I in Italian is pronounced like the letter E in English and the Letter E in Italian is pronounced like the letter A in English. This can be confusing at times like this' (39. D.K.M.G., Educator, Museo Galileo, Italy).
Yes, (41. J.A.A., Head of the Science Center, Oslo Science Center, Norway).
- No, (42. N.D., Coordinator of Science Exhibitions, Belgrade's Science festival and Science Park Belgrade, Serbia).
- Yes, (43. M.B., Director of Media and Learning Center, Experimentarium, Denmark).
- Yes, (44. P.K., Director, AHHAA Science Centre, Estonia).
- Yes, (45. A.O., Director, Vísindasmiðjan, Iceland).
- Yes, 'In my opinion different visual cultures concerns the design of the whole exhibition. My impression is, that e.g. in some cultures it is important to create very colorful exhibition spaces with many bright colors, whereas compared to this in Germany and other European countries the exhibition design often is rather reduced to a few colors or white or black rooms, in which the exhibits are located' (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).
- Yes, 'Bad practice not to consult the client, I have never found this exhibit convincing' (53. S.P., Director, Observatory Science Centre, UK).
- No, 'We do not have that experience' (54. T., Curator, Danish Museum of Energy, Denmark).
- Yes, 'Yes, if it is connected to language system. No, if it is a part of popular visual symbols/system or, at least, to sign system which may vary not only because of cultural concepts' (106. D.E., Head of Exhibitions and Publishing, Center for the Promotion of Science, Serbia).
- No, 'The use of text panels, concept cartoons and whatever interpretation we choose to use need to be adapted to the needs (literacy levels, stylistically etc) of the local audience. I think it is too broad to say that confusion is caused by using the tool. Confusion is caused by not using the tool appropriately. In reference to the Vocal Vowels exhibit, if the sounds do not exist in the visitor's language, then why, why, why have the exhibit in the first place? All our exhibits should connect our audiences to science and help them to make sense of THEIR world. If this exhibit was to be re-interpreted to 'teach' the vowel sounds of the English language for example, then it could make their engagement with the exhibit more rational. We have this same exhibit in Thinktank and also purchased from Techniquest as you have no doubt purchased yours. It is well used in our centre and popular - it is a good exhibit in the right context' (111. C.L., Exhibitions Manager, Thinktank Birmingham Science Museum, UK).
- No, (112. I.F., Centro Ciência Viva de Bragança, Coordinator of explainers, Portugal).
- Yes, (113. N.V., Educator, Technotown, Italy).
- No, (117. G.B., Curator, Tyne and Wear Archives & Museums, UK).
- Yes, 'It may be that the exhibit assumes too much prior knowledge on behalf of the visitor' (121. M.S., Team Leader, Science Museum London, UK).

(4) Middle East

(5) North America
- Yes, 'Yes - again, as mentioned this can be a result of poor design choices and not actually working with and understanding your intent and message' (8. D.H., director, TELUS Spark, Canada).
- Yes, 'Text on signs... Language issues' (12. Anonymous, curator, Kalamazoo Aviation History Museum, USA).
- Yes, 'I am not clear about the question here but interpreting illustrations can affect people - we know that adding images of girls in signage causes more girls to try exhibits' (13. L.M., researcher, Arizona Science Center, USA).
- Yes, 'For example the guttural sounds in the French language are nonexistent in English, and even though it is possible to teach how to make the sounds, it is not easy to take off the cultural aspect for each person' (14. Anonymous, educator, Planetario Alfa, Mexico).
- Yes, 'Again, "yes" but "so what?" You learn from these differences, misconceptions etc. This is one of the most fundamental values of science: looking at the world with fresh eyes. Trying for homogenization of interpretation is absurd' (21. D.D., curator, MIT Museum, USA).
- No, 'This is a confused question: there are visual cues that one may assume to be universal; however this question is asking about visual cartoons...yet describes the differences between languages..so the answer is both yes and no' (28. Anonymous, Exhibitor, Berkshire museum, USA).
- Yes, 'The cartoon has incorrect information. Oxygen is not an inert gas for one and plasma balls have an atmospheric pressure that is much lower than the outside air pressure. It is an example of translation without context or knowledge of the language. Vocal Vowels would make more sense if it used regional sounds, but museums buy their exhibits form outside companies who do not
understand these issues and build exhibits based on their own experience' (35. K.P. Director of Exhibit Services, Exploratorium, USA).


- Yes, (57. R.S., Executive Associate Director, Exploratorium, USA).


- Yes, 'The point about the particular sound not being used in a guest's language is a good one' (62. R.L.F., Director, Clay Center for the Arts & Sciences, USA).

- No, 'For this as well as the other exhibits, evaluation (at whatever stage) could help us know for sure, but sounds are sounds whether or not they are sounds you make on a regular basis' (63. D.J., Educator, Clark Planetarium, USA).

- Yes, (64. H.H., Director, Connecticut Science Center, USA).

- No, 'I have not witnessed this' (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).


- Yes, 'Some visitors don't understand why a woman is shown performing scientific experiments, some cultures view women as inferior so they dismiss the exhibit all together' (67. G.B. Curator, SciTech Hands On Museum, USA).

- No, 'It does not seem like the confusion would be culturally based' (69. S., Exhibit Developer, Creative Discovery Museum, USA).

- Yes, (72. Anonymous, Educator, Columbia Memorial Space Center, USA).

- Yes, (73. H.S., Director, Durango Discovery Museum, USA).

- Yes, 'This also goes to the point of prior experience, prior knowledge, and your expected learning outcomes. Someone once said to me that signs are needed for exhibits that are poorly designed. It was an exaggeration but the point is that people could learn a lot at the vocal vowels exhibit if they only know two things - they have vocal cords that move or change shape, and the shape influences the sound. Neither of those things need text' (74. E.M., Educator, Explora, USA).

- Yes, (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).

- Yes, ‘Spelling out sounds is difficult when multiple languages are considered’ (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).

- No, (80. Anonymous, Education Manager/Staff Scientist, Connecticut Science Center, USA).

- Yes, ‘Yes, however I do not think that culturally biased exhibits should never be used. We need to be aware of the biases though’ (81. Anonymous, Director, Explora, USA).

- Yes, ‘Most likely it makes sense to me that drawings or illustrations often depict certain people and concepts, the drawing example here suggests that a certain level of knowledge about the concepts presented is needed to understand the component, the Vocal Vowels exhibit seems more straightforward and understandable’ (82. J.J.R., Director, Science Museum of Minnesota, USA).


- No, (84. Anonymous, Educator, Sony Wonder Technology Lab, USA).


- No, ‘The creative design of an exhibit can help people understand a concept and perhaps the design does not need to be so complicated to explore the concept’ (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, ‘In some cases some devices may be unfamiliar to some people, but they should still be able to explore it and get some meaning from it’ (87. D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, (88. S.R., Researcher, Lawrence Hall of Science, USA).


- Yes, ‘Foreign visitors continue to open emergency exit doors even though graphic signs ask them not to’ (90. L.L., Director, Ocean Star Offshore Drilling Rig Museum: Offshore Energy Center, USA).


- Yes, ‘I always find illustrations particularly fraught with potential misunderstandings’ (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).


- No, (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).

- Yes, (96. N.T., Director, Houston Museum of Natural Science: HMNS, USA).

- Yes, (97. Anonymous, Project Director of Exhibits and Programs, Sciencenter, USA).

- No, ‘You can find or create cultural confusion with most anything you do. The central question has to do with your intent and the calibre of help you have on the floor’ (98. C.M., CEO: Chief Executive Officer, Miami Science Museum, USA).

- Yes, ‘Yes - please reference Scott McCloud’s book, “understanding comics” - different cultures interact with visual mechanisms in different ways’ (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).

- Yes, (103. D.R., Director, Fleischmann Planetarium and Science Center, USA).

- Yes, ‘We also test illustrations along with instructional text to make sure that visitors understand. I have seen many instances of the design team thinking something is clear and visitors not understanding’ (104. M.B., Researcher, The Franklin Institute, USA).

- Yes, ‘Yes, but haven't seen this in our museums’ (108. J.H., Director of Education, GWIZ - The Science Museum, USA).

(6) Oceania

- Yes, ‘I imagine that if there is cultural confusion over the drawings there will be confusion in general. However it is possible that combined with any language barrier issues that people may struggle to understand this example’ (5. S.S., curator, Excite centre - Waikato Museum, New Zealand).


- Yes, (30. A.H., Director, Scitech, Australia).

- Yes, ‘Trying to show how fingers or hands should stroke something as part of instructions is difficult to show in illustrations (using arrows and stepped illustrations) without generating confusion’ (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

- Yes, ‘If the exhibit is designed well there should be a minimum of words’ (37. C.W., Exhibitor, Monash Science Centre, Australia).
- Yes, ‘Sometimes the intention cannot be portrayed properly using visual mediums. We use animations without text to try and tell a story’ (55. Anonymous, Museum Supplier, Grande Exhibitions, Australia).

- Yes, (61. A.B., Director, Scitech, Australia).

(7) Russia

- Yes, ‘Each exhibition should be adopted for the country specifics (talking about sounds). Visual culture: I don’t think that Russians will fully accept cartoons with non-European type of face’ (119. I.K., Director, Experimentarium Science center, Russia).

(8) South America

- Yes, (68. A.C.P., Director, Espaço Ciência, Brazil).

- Yes, (70. F.A., Director, Centro interactivo de Ciencias - La Punta, Argentina).

- Yes, ‘I can’t answer very accurately this question, but I’m sure that not all the citizens have the same codes to understand some of the texts or exhibits’ (71. C.A., Educator, Parque Explora Medellín, Colombia).

- Yes, ‘Not only the cartoons, but also the colors and design are intrinsically linked to the exhibit’ (75. M.K., Evansville, Former Director, Brazil).

- No, (79. V.P., Educator, Espacio Ciencia LATU, Uruguay).

- Yes, ‘Visual aids are not equally useful for every visitor. It strongly depends on their cultural background. Function graphs are one example, as structure schemes are. Nonetheless their use is justified for those who benefit from them and for presenting another challenge for the others’ (101. M.H., Designer, Ciencia Viva, Uruguay).

- Yes, (102. M.E.V., Educator, Museu de Astronomia e Ciências Afins: MAST, Brazil).

- Yes, ‘again, it is a group of different topics, that make the difference’ (107. E.H., Director, Maloka, Colombia).

- Yes, (114. P.D.S., Director, Museo del Mar, Argentina).

- No, ‘Regarding the visual part we believe there isn’t a confusion because the cartoons can be understood easily. Regarding the sound we believe that it could generate many problems because of the different sounds of the diverse languages’ (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).

- Yes, ‘Between Spanish and English the vowels sound is very different’ (116. V.V., Educator, Museo Interactivo Mirador: MIM, Chile).
13. Conceptual understanding:
For example, many children believe that light comes from the eyes to the object. This was an idea held by the ancients and in modern times reinforced by viewing comics and fairy tales such as Superman had laser eyes. The exhibit ‘Pepper's Ghost’, where international visitors can confuse the concepts of light and vision. Do you believe there are cultural issues in interactive exhibits where the emphasis is on understanding a concept?

Please explain your answer, if one of your exhibits shows this issue.

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<td>- Yes, (100. J.J.A., Director, Ghana Planetarium Science Centre, Ghana).</td>
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<td>- ‘Yes, I certainly do believe that conceptual understanding is linked to cultural issues. In South Africa there are many myths which surround the concept of lightning. This in many cases influences the visitors understanding of the concepts because lightning is often viewed as a supernatural occurrence. This influences the understanding in exhibits such as the Jacobs ladder in our centre’ (105. M., Science Centre Manager, Sci-Bono Discovery Centre, South Africa).</td>
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<td>- ‘Yes, Yes of course’ (109. A.Z., Director, Tunis Science City, Tunisia).</td>
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<td>- Yes, (120. A.L., Educator, Cape Town Science Centre, South Africa).</td>
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<tr>
<td>(2) Asia</td>
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<td>- Yes, ‘Cultures develop certain beliefs in minds of society. Sometimes these beliefs become barriers in understanding the concept of science’ (9. S.J.S., curator, Science City Kolkata, India).</td>
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<td>- Yes, ‘If you place a statue of deity etc. for explaining some concept, people will put money. Also we had a transparent glass women show. Due to cultural issue only it was titled I am a Mother. As the word mother stops all controversies’ (19. U.K., curator, Nehru Science Centre, India).</td>
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<td>- No, (23. K.C.C., volunteer, National Museum of Natural Science in Taiwan, China).</td>
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- No, (36. A.C.J., Director, Science Discovery Center, Philippines).

- No, (38. C.L.L., Evaluator, Science Centre Singapore, Singapore).

- No, 'Not for Singapore as the key language for learning here is in English' (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).

- Yes, 'Some visitors have culturally pre-conditioned mindset or ideas, but we only show or illustrate concepts which are scientifically correct without referring to misconceptions that they might have picked up from individual cultures' (49. E.I., Director, Birla Industrial & Technological Museum: BITM, India).


- No, 'I am not sure whether to define this issues as cultural issues. I think they can be related to misconceptions revealed by research or caused by teaching. These are issues to take into account when designing exhibits but I am not sure that the definition of cultural (different countries?) applies here' (56. D.A.P., Curator, Bloomfield Science Museum Jerusalem, Israel).

- No, (58. O., Curator, Communications Museum of Macao, China).

- Yes, 'In different countries children separate intuition and reality at different ages and in some cases never' (60. M.B., Science Show and Exhibit Design Consultant, National Science Museum, Thailand).

(3) Europe

- Yes, (1. C.J., Science Communicator, UK).

- No, 'I have never encountered this effect' (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).

- Yes, 'I’m sure there are examples of cultural idioms and expressions which affect how the local population views certain concepts. We have this difficulty with one of our science demonstrations which uses a Tesla Coil to exemplify lightning. Many people think all lightning travels from the sky towards the ground, as that is how it is typically portrayed on TV, yet we know that lightning often 'arises' from the ground and travels towards the sky, not to mention sheet lightning and other similar phenomena' (3. S.W, educator, Benjamin Franklin House, UK).

- Yes, 'A misconception may exist in a person’s mind because of a multitude of factors, including cultural. If an exhibit seeks to ‘teach’ a concept then, it must address misconceptions' (4. D.S., Interpretation assistant, Glasgow Science Centre, UK).

- Yes, (6. Anonymous, educator, Porthcurno Telegraph Museum,
- Yes, (15. H.H., director, Pike Science Centre, Finland).

- Yes, (16. S.D., assistant to the management board, Deutsches Hygiene Museum Dresden, Germany).

- Yes, (17. P.S., director, Serlachius Museums, Finland).


- Yes, 'Children very often try to give explanation to natural phenomena using their imagination and personal experiences. Many times they come to wrongful conclusions. It is up to the facilitators of the Science Centre to discover these misconceptions. For example, in the brachistochrone exhibit most students will say that the fastest path is the straight line and not the curved one' (24. A.C., project manager, Centre for Science Education (CSE), Greece).


- Yes, 'We have many exhibits about mirrors and kaleidoscopes. The simplest, but one of the most interesting and astonishing, asks to visitor to put himself in front of a normal mirror, close one eye and draw the silhouette of his face, after wondering: how big does my face appear in the mirror? Smaller, bigger or equal to your face? Does it depend from the distance between mirror and face? After the experience: how does it work? Why the image is smaller than your face? How much smaller? Why it keeps the same when you go closer or farer from the mirror? Why it doesn't happens for an external observer?' (27. G., Sub-Director, mmaca Museu de Matemàtiques de Catalunya, Spain).

- Yes, (29, J.Š., Educator, iQpark, Czech Republic).

- Yes, (33. P.J., Exhibition Manager, Heureka, the Finnish Science Centre, Finland).

- Yes, 'Undoubtedly younger people are influenced by cartoons and other external affects, and as science explainers it is our job to anticipate and counteract these assumptions' (34. S.A., Educator, National Space Centre, UK)


- No, (41. J.A.A., Head of the Science Center, Oslo Science Center, Norway).

- No, 'I think that the visitors will understand the Pepper’s ghost even if they have the false understanding of how do we see things. You can understand it in both ways, but through explanation you will learn what is the right answer’ (42. N.D., Coordinator of Science Education, UK).
Exhibitions, Belgrade’s Science festival and Science Park Belgrade, Serbia.

- Yes, (43. M.B., Director of Media and Learning Center, Experimentarium, Denmark).

- No, (44. P.K., Director, AHHAA Science Centre, Estonia).

- Yes, (45. A.O., Director, Visindasmiðjan, Iceland).

- Yes, ‘I believe there is mainly a big difference in the choice of topics’ (46. L.H., Educator, Science Centre Delft: TUDelft, Netherlands).


- Yes, (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).

- Yes, ‘There are plenty of adults as well as children who have these ideas in any culture’ (53. S.P., Director, Observatory Science Centre, UK).

- No, (54. T., Curator, Danish Museum of Energy, Denmark).

- No, ‘I don't know the concept of Pepper's Ghost, so I can not make any suggestions on this’ (106. D.E., Head of Exhibitions and Publishing, Center for the Promotion of Science, Serbia).

- Yes, ‘I believe that there are cultural issues that prevent understanding a concept. And certainly a lot of media can create or reinforce misconceptions. The pepper's ghost set-up is a theatre trick borrowed by the museum world. It is meant to trick our sense of vision, so using this exhibit to teach the concept of vision is like using an illusion as an example of how well our eyes work (which they don't!). A better example of cultural issues as a block to conceptual understanding is in the cases of inner city children who have never seen a live cow and only ever eat processed foods, have difficulty linking their hamburger with a cow. As a last point, this is a general barrier to learning rather than in using or operating an interactive exhibit successfully’ (111. C.L., Exhibitions Manager, Thinktank Birmingham Science Museum, UK).

- Yes, (112. I.F., Centro Ciência Viva de Bragança, Coordinator of explainers, Portugal).

- Yes, (113. N.V., Educator, Technotown, Italy).

- No, (117. G.B., Curator, Tyne and Wear Archives & Museums, UK).

- No, 'Not so much a cultural issue, more likely to be dependent on age or experience' (121. M.S., Team Leader, Science Museum London, UK).

(4) Middle East

(5) North America
- No, (7. Anonymous, interpretation specialist, National Parks and National Historic Sites, Canada).
- Yes, 'This can be addressed through appropriate design and understanding the naive worldviews that may be brought into the experience. This particular example doesn't really fit a "cultural" motif - it is actually a common misunderstanding and naive view across a range of ages. Cultural context can be an influencer (see for example exhibits that are dependent upon eye contact between participants)' (8. D.H., director, TELUS Spark, Canada).
- Yes, 'There are both developmental and cultural issues on this' (13. L.M., researcher, Arizona Science Center, USA).
- Yes, 'Many different countries have different meaning to the same word or concept, so what it might mean something to one culture, might mean something completely different to another' (14. Anonymous, educator, Planetario Alfa, Mexico).
- No, 'Isn't the point of the exhibit to explain the concept?' (28. Anonymous, Exhibitor, Berkshire museum, USA).
- No, 'Superman had x-ray vision. I don't think that this suffers from cultural issues so much as it suffers from poor fundamental design execution' (35. K.P. Director of Exhibit Services, Exploratorium, USA).
- Yes, (51. M. Bilingual Evaluation Assistant, Oregon Museum of
Science and Industry: OMSI, USA).

- Yes, (57. R.S., Executive Associate Director, Exploratorium, USA).


- No, (62. R.L.F., Director, Clay Center for the Arts & Sciences, USA).

- No, (63. D.J., Educator, Clark Planetarium, USA).

- Yes, (64. H.H., Director, Connecticut Science Center, USA).

- No, 'I have not witnessed this' (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).

- No, 'Is it cultural or educational?' (66. L.C., Exhibitor, The Tech Museum, USA).

- Yes, 'Yes, we have an isotopes exhibit that is rather complicated and it just collects dust' (67. G.B. Curator, SciTech Hands On Museum, USA).

- No, 'This is a cultural issue to me only in the manner to which science is taught and understood in different cultures/countries' (69. S., Exhibit Developer, Creative Discovery Museum, USA).

- Yes, (72. Anonymous, Educator, Columbia Memorial Space Center, USA).

- Yes, (73. H.S., Director, Durango Discovery Museum, USA).

- No, 'Give the people tools with which to investigate the phenomenon. Will lights and switches in different location allow them to get a better idea about what is producing the 'ghost' help them understand the concept. There is no need for them to have a complete understanding, nor should we as scientists/educators ever believe that we have a complete understanding and are the suppliers of all knowledge' (74. E.M., Educator, Explora, USA).

- No, (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).


- Yes, 'Depends on how the concept is explained' (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).

- Yes, 'Different cultures have different superstitions which would shape their understanding of science concepts' (80. Anonymous, Education Manager/Staff Scientist, Connecticut Science Center, USA).

- Yes, (81. Anonymous, Director, Explora, USA).
- Yes, 'Culture is intrinsic to who we each are, to assume that culture does not impact on everything we do or impact on museum concepts or how visitors will experience a component is underestimating the power that culture has on how we experience the world' (82. J.J.R., Director, Science Museum of Minnesota, USA).


- Yes, (84. Anonymous, Educator, Sony Wonder Technology Lab, USA).


- No, 'I think there are many ways for people to explore this concept including day and night and light from the sun on the moon etc. I think that the stimulus cues are critical in helping people explore. These can be given in very few words. Or audio cues' (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, 'Long held beliefs on how the world works can be barriers to learning science, for any culture. The role of science centers is to help people understand the science, and challenge beliefs' (87. D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, (88. S.R., Researcher, Lawrence Hall of Science, USA).


- No, 'I believe this is more an age appropriate issue rather than culture issue’ (90. L.L., Director, Ocean Star Offshore Drilling Rig Museum: Offshore Energy Center, USA).


- Yes, (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).


- Yes, 'All cultures understand differently' (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).

- Yes, 'Once again. Poor exhibit design' (96. N.T., Director, Houston Museum of Natural Science: HMNS, USA).

- Yes, (97. Anonymous, Project Director of Exhibits and Programs,
- No, 'See the answer above' (98. C.M., CEO: Chief Executive Officer, Miami Science Museum, USA).

- No, 'I accept that there may be cultural issues that could reveal themselves during prototyping and therefore should be addressed so the exhibition does not defeat the average user, however I think that revealing the nature of phenomenon is the purpose of most science interactive - if the user's cultural preconceptions are so strong that they can't fairly investigate the phenomenon than I'm really not sure how you get around that.... only comparable I can come up with are people who can't accept evolution for reasons of religion - no matter how clear the exhibit may be - they won't accept it' (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).

- No, (103. D.R., Director, Fleischmann Planetarium and Science Center, USA).

- Yes, 'Different cultures have different "naive notions" or widespread misconceptions about how things work. Exhibits can confuse things even further' (104. M.B., Researcher, The Franklin Institute, USA).


- Yes, (30. A.H., Director, Scitech, Australia).

- Yes, 'I avoid showing arrows coming from eyes so the 'light from eyes' misconception is not reinforced' (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

- Yes, (37. C.W., Exhibitor, Monash Science Centre, Australia).


- Yes, (61. A.B., Director, Scitech, Australia).

(6) Oceania

- No, 'I believe good design, and graphics should be able to surpass any preconceived ideas' (5. S.S., curator, Exscite centre - Waikato Museum, New Zealand).

(7) Russia

- No, 'The aim of each exhibition is to bring knowledge and be as transparent and true as possible. It should not be an issue of an exhibition' (119. I.K., Director, Experimentarium Science center,
Russia).

(8) South America

- Yes, (68. A.C.P., Director, Espaço Ciência, Brazil).
- No, (70. F.A., Director, Centro interactivo de Ciencias - La Punta, Argentina).
- Yes, ‘We have an exhibit trying to understand nanoscience and nanotechnology, where difficult concepts of scale are discussed. We made several studies prior to the design of the exhibit to understand how the children perceive these concepts’ (75. M.K., Evansville, Former Director, Brazil).
- No, (79. V.P., Educator, Espacio Ciencia LATU, Uruguay).
- Yes, ‘Can't understand the question here. A number of the exhibits deal with unclear concepts’ (101. M.H., Designer, Ciencia Viva, Uruguay).
- No, ‘Light and a cat. Does the animal emit light as a lamp? I think the preconception usually is a construction did by yourself to explain something. This can be the same in different cultures. It more linked with a conceptual understanding’ (102. M.E.V., Educator, Museu de Astronomia e Ciências Afins: MAST, Brazil).
- Yes, ‘Yes, of course. The concept is more important than the information. We should share with them the importance of Observing, Thinking’ (107. E.H., Director, Maloka, Colombia).
- Yes, (114. P.D.S., Director, Museo del Mar, Argentina).
- No, ‘More than cultural problem the error is because they have not learned the concept properly, because vision and light for example, are universal concepts that must be learned the same way by everyone’ (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).
- Yes, (116. V.V., Educator, Museo Interactivo Mirador: MIM, Chile).

14. Social Issues:
For example, Thai people greet each other with a Wai (put the palms of the hands together). Western people and others shake hands. In the ‘Real Image’ exhibit, the visitor is required to shake hands with their own reflected hand. Confusing for Thai visitors? Do you believe that cultural issues can involve social behaviour?

Please explain your answer, if one of your exhibits shows this issue.
Cultural regions | The experts comment
--- | ---
(1) Africa | - Yes, (100. J.J.A., Director, Ghana Planetarium Science Centre, Ghana).
- Yes, ‘I believe that social issues often influence learning in a science centre. In some cultures in South Africa it is impolite for a young person to teach or explain a concept to an older person, this can cause problems in the centre when one of our young explainers tries to talk to an older experienced teacher’ (105. M., Science Centre Manager, Sci-Bono Discovery Centre, South Africa).
- Yes, ‘Obviously cultural issues can involve social behaviour’ (109. A.Z., Director, Tunis Science City, Tunisia).
- Yes, (120. A.L., Educator, Cape Town Science Centre, South Africa).
(2) Asia | - Yes, ‘Exhibit needs to explain shake hand visual showing folded hands. Here it seems culture over powered the actual need to explain the exhibit’ (9. S.J.S., curator, Science City Kolkata, India).
- Yes, ‘This question is not clear to me. So far as exhibit operation is concerned the answer is yes. Visitors always go to left when entering the hall. It is from social behaviour as in India we are left hand drive’ (19. U.K., curator, Nehru Science Centre, India).
- Yes, (22. C.L., researcher, National Museum of Natural Science in Taiwan, China).
- No, (23. K.C.C., volunteer, National Museum of Natural Science in Taiwan, China).
- No, (36. A.C.J., Director, Science Discovery Center, Philippines).
- Yes, 'I guess that in some culture, that will be an issue. But with most cosmopolitan places, this will not be so much of an issue as they are exposed to different cultures' (38. C.L.L., Evaluator, Science Centre Singapore, Singapore)
- No, (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).
- No, 'I marked 'no' to it because in India too we fold our hands to greet people. But in front of the same exhibit here, people do not feel culturally inhibited to stretch their hands to try the exhibit' (49. E.I., Director, Birla Industrial & Technological Museum: BITM, India).
- Yes, 'We need to learn different customs and fit into the common culture’ (50. Anonymous, Designer, China Science and Technology
- Yes, 'These can be rated also to whether visitors touch each other, talk to each other or feel comfortable looking at each other, or letting others look at what they are doing. Something related with norms of behaviour' (56. D.A.P., Curator, Bloomfield Science Museum Jerusalem, Israel).

- Yes, (58. O., Curator, Communications Museum of Macao, China).

- Yes, 'Very much so as the exhibit requires shaking hands an almost only European gesture to indicate no weapon' (60. M.B., Science Show and Exhibit Design Consultant, National Science Museum, Thailand).

(3) Europe

- Yes, (1. C.J., Science Communicator, UK).

- Yes, 'The shake hands exhibit is designed for a particularly western gesture. BUT, the phenomenon is independent of the cultural artefact and an alternative design could be imagined that did not require the same gesture' (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).

- Yes, (3. S.W, educator, Benjamin Franklin House, UK).

- Yes, 'Again, exhibits should take advantage of 'immediate apprehend ability', which is closely linked to culture. What is a natural social behaviour in one context may be different in other cultures' (4. D.S., Interpretation assistant, Glasgow Science Centre, UK).


- Yes, (15. H.H., director, Pike Science Centre, Finland).

- Yes, (16. S.D., assistant to the management board, Deutsches Hygiene Museum Dresden, Germany).

- Yes, (17. P.S., director, Serlachius Museums, Finland).


- Yes, (24. A.C., project manager, Centre for Science Education (CSE), Greece).

- Yes, 'This exhibit could also be considered confusing for Western people, as it's not normal to shake hands with yourself' (25. Anonymous, Exhibit Manager, Eureka! The National Children's Museum, UK).

- Yes, 'see answer 9' (27. G., Sub-Director, mmaca Museu de
Matemàtiques de Catalunya, Spain).

- Yes, (29. J.Š., Educator, iQpark, Czech Republic).

- Yes, (33. P.J., Exhibition Manager, Heureka, the Finnish Science Centre, Finland).

- Yes, 'But again, I think as long as instructions are implicit this is not a problem' (34. S.A., Educator, National Space Centre, UK).

- Yes, 'There are many cultural issues that involve social behaviour like wearing shoes at all times even indoors of your own home. The way an Italian waves goodbye and motions to move closer can often be misread by Americans as well' (39. D.K.M.G., Educator, Museo Galileo, Italy).

- Yes, (41. J.A.A., Head of the Science Center, Oslo Science Center, Norway).

- Yes, (42. N.D., Coordinator of Science Exhibitions, Belgrade's Science festival and Science Park Belgrade, Serbia).

- Yes, (43. M.B., Director of Media and Learning Center, Experimentarium, Denmark).

- Yes, (44. P.K., Director, AHHAA Science Centre, Estonia).

- Yes, (45. A.O., Director, Visindasmiðjan, Iceland).

- Yes, 'We have a lot of exhibits which do not reveal any information until touched or switched on by visitors. We are a self-confident and inquisitive people that simply do that. Foreigners are usually more reluctant' (46. L.H., Educator, Science Centre Delft: TUDelft, Netherlands).


- Yes, (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).

- Yes, 'Most people get to experiment with this exhibit without reading anything, the fascination with the hand and image seems universal whatever the exhibit is called in my experience' (53. S.P., Director, Observatory Science Centre, UK).


- Yes, 'Yes, it is possible, but in the modern times many national customs are much more familiar to wider audiences, not only to professionals in humanities' (106. D.E., Head of Exhibitions and Publishing, Center for the Promotion of Science, Serbia).

- Yes, (111. C.L., Exhibitions Manager, Thinktank Birmingham
- Yes, (112. I.F., Centro Ciência Viva de Bragança, Coordinator of explainers, Portugal).
- Yes, (113. N.V., Educator, Technotown, Italy).
- Yes, 'This is avoided if you avoid the term 'shake hand', and merely keep it simple like 'move your hand towards the mirror' ' (121. M.S., Team Leader, Science Museum London, UK).

(4) Middle East

(5) North America
- Yes, 'Gestures differ when we meet, depending on where we're from Language issues' (12. Anonymous, curator, Kalamazoo Aviation History Museum, USA).
- Yes, 'You mention a good example. We have seen kids have to adjust to touching things in our museum since parents may want them well-behaved = don't touch' (13. L.M., researcher, Arizona Science Center, USA).
- Yes, 'All cultures have different ways to express themselves in a non-verbal way, which produces a cultural issue between different countries' (14. Anonymous, educator, Planetario Alfa, Mexico).
- Yes, 'but one would expect the exhibit to prompt the visitor' (28. Anonymous, Exhibitor, Berkshire museum, USA).
- Yes, 'Again the cultural confusion derives from a poor
understanding of the exhibit and a failure to make an change in the activity' (35. K.P. Director of Exhibit Services, Exploratorium, USA).


- Yes, (57. R.S., Executive Associate Director, Exploratorium, USA).


- Yes, (64. H.H., Director, Connecticut Science Center, USA).

- Yes, 'However, I believe that most people are open to other cultures customs and would attempt them if given the proper instruction' (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).


- Yes, 'Some parents keep children close by while others let the children roam the museum freely, some are concerned with safety, control or social behavior of their children in public' (67. G.B. Curator, SciTech Hands On Museum, USA).

- Yes, (69. S., Exhibit Developer, Creative Discovery Museum, USA).

- Yes, (72. Anonymous, Educator, Columbia Memorial Space Center, USA).

- Yes, (73. H.S., Director, Durango Discovery Museum, USA).

- Yes, 'In the example you have given the instructions are based on a social convention not a fundamental aspect of human behaviors. If the sign told people to 'touch' their own reflected hand you would be eliciting a behavior common to all people regardless of culture' (74. E.M., Educator, Explora, USA).

- Yes, (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).


- Yes, 'There would be some confusion if the directions (or images) are not made properly' (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).
- Yes, (80. Anonymous, Education Manager/Staff Scientist, Connecticut Science Center, USA).

- Yes, ‘Exhibits should be developed in many different cultures, not just imported. If purchased, exhibits like this should be modified if reaching a hand out is culturally offensive or inappropriate’ (81. Anonymous, Director, Explora, USA).

- No, ‘Cultural norms such as shaking hands, bowing or putting palms of the hands together are how important aspects of how we interact with others. I don’t think this would be confusing - as hand shaking is understood as a western style of greeting it may be less welcoming to Thai visitors’ (82. J.J.R., Director, Science Museum of Minnesota, USA).


- Yes, (84. Anonymous, Educator, Sony Wonder Technology Lab, USA).


- Yes, ‘We have, as part of one of our larger exhibitions, a section on ways different cultures handle death. Again, if the purpose is to share customs, then social behaviors in other countries are great. We have done that with sharing the Indian culture in a comprehensive way with our Indian community here. We had a large exhibition, many events and a free movie, Mystic India, for all the school children. We embrace all cultures and it is a wonderful way to learn about each other’ (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, ‘Yes but in this example, I believe a person would try the motion, even if the concept of shaking hands is not familiar. If something is offensive to a culture, then I assume they would just not attempt that exhibit’ (87. D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, (88. S.R., Researcher, Lawrence Hall of Science, USA).


- Yes, (90. L.L., Director, Ocean Star Offshore Drilling Rig Museum: Offshore Energy Center, USA).


- Yes, (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).


- Yes, 'Cultural issues can absolutely involve social behavior' (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).

- Yes, (96. N.T., Director, Houston Museum of Natural Science: HMNS, USA).

- Yes, (97. Anonymous, Project Director of Exhibits and Programs, Sciencenter, USA).

- Yes, 'But so what -- if you have a center in Thailand have the exhibit require a Wai. Otherwise don't worry about it' (98. C.M., CEO: Chief Executive Officer, Miami Science Museum, USA).

- No, 'I would in this case suggest the exhibition premise is simply postured in a different context. For example joining hands for some other reason than greeting' (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).

- Yes, (103. D.R., Director, Fleischmann Planetarium and Science Center, USA).

- Yes, 'I can't think of a specific example, but the one you give above is very clear' (104. M.B., Researcher, The Franklin Institute, USA).


(6) Oceania

- Yes, 'This is the first clear example of a 'cultural issue' and shows how broad thinking around these issues could have overcome this issue by using the same exhibit but differing action "the two of you" (5. S.S., curator, Exscite centre - Waikato Museum, New Zealand).


- Yes, (30. A.H., Director, Scitech, Australia).

- Yes, 'It's culturally inappropriate to show nudity, death in the animal or human world, etc., which can impact on communicating messages about health' (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

- Yes, (37. C.W., Exhibitor, Monash Science Centre, Australia).

- Yes, 'Definitely. We constantly have to adapt our exhibitions and how they are presented to different cultures' (55. Anonymous, Museum Supplier, Grande Exhibitions, Australia).
(7) Russia

- Yes, ‘This is a part of the game’ (119. I.K., Director, Experimentarium Science Center, Russia).

(8) South America

- Yes, (68. A.C.P., Director, Espaço Ciência, Brazil).
- Yes, (70. F.A., Director, Centro interactivo de Ciencias - La Punta, Argentina).
- Yes, ‘Interesting issue, but we don’t have similar issues here’ (75. M.K., Evansville, Former Director, Brazil).
- Yes, (79. V.P., Educator, Espacio Ciencia LATU, Uruguay).

- No, ‘Can’t come up with one example of such issue in our exhibits’ (101. M.H., Designer, Ciencia Viva, Uruguay).
- Yes, ‘For instance, with an apparatus that you need to manipulate, you are sometimes confuse if it is or not forbidden to touch since you are educated to not touch on things’ (102. M.E.V., Educator, Museu de Astronomia e Ciências Afins: MAST, Brazil).
- Yes, ‘Social behavior is part of cultural issues. You can’t separate them’ (107. E.H., Director, Maloka, Colombia).
- Yes, (114. P.D.S., Director, Museo del Mar, Argentina).

- Yes, ‘We have the same exhibit but being at a western civilization we do not have these cultural differences, but we understand that for a Thai it could be confusing’ (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).

- No, ‘You can use another kind of invitation, in our case we don’t use the greeting how the invitation to the exhibit’ (116. V.V., Educator, Museo Interactivo Mirador: MIM, Chile).
15. Emotional values:
For example, there are many symbols used to affect the emotions such as candles, music, fireworks, colours in funerals and celebration parties. The magnetic forces exhibit visitors may be irritated, annoyed or happy to solve it. Do you believe cultural differences influence emotional reactions?

Please explain your answer, if one of your exhibits shows this issue.

<table>
<thead>
<tr>
<th>Cultural regions</th>
<th>The experts comment</th>
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<tbody>
<tr>
<td>(1) Africa</td>
<td></td>
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<tr>
<td></td>
<td>- Yes, (100. J.J.A., Director, Ghana Planetarium Science Centre, Ghana).</td>
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<td></td>
<td>- Yes, (105. M., Science Centre Manager, Sci-Bono Discovery Centre, South Africa).</td>
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<td></td>
<td>- Yes, ‘yes of course’ (109. A.Z., Director, Tunis Science City, Tunisia).</td>
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<td>- No, (120. A.L., Educator, Cape Town Science Centre, South Africa).</td>
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<tr>
<td>(2) Asia</td>
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<td></td>
<td>- Yes, 'Objects are used for different purposes in our daily lives. Some for pleasure, happiness, sorrow etc.' (9. S.J.S., curator, Science City Kolkata, India).</td>
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<td>- Yes, 'It is true. In laughing mirror exhibits such reactions are commonly visible' (19. U.K., curator, Nehru Science Centre, India).</td>
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<td>- Yes, (22. C.L., researcher, National Museum of Natural Science in Taiwan, China).</td>
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<td></td>
<td>- No, (23. K.C.C., volunteer, National Museum of Natural Science in Taiwan, China).</td>
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<td>- Yes, 'Facial expressions vary per culture. ie. in the Philippines, even in the face of problems or adversity majority still smile when interacting with a person' (36. A.C.J., Director, Science Discovery Center, Philippines).</td>
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<tr>
<td></td>
<td>- No, (38. C.L.L., Evaluator, Science Centre Singapore, Singapore)</td>
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<td></td>
<td>- No, (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).</td>
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<td>- Yes, 'I believe so but we have so far not faced such a situation. Everybody seems to enjoy playing with our 'identify a magnet' exhibit' (49. E.I., Director, Birla Industrial &amp; Technological Museum):</td>
</tr>
</tbody>
</table>
- No, 'In exhibition design, we try our best to do ergonomic and user-centre design to make audience comfortably use the interactive interface, minimize any interference' (50. Anonymous, Designer, China Science and Technology Museum, China).

- No, 'I am not aware of research on these areas. We know for example that blood exhibits annoy visitors in some countries, and not in others, but this is anecdotal knowledge' (56. D.A.P., Curator, Bloomfield Science Museum Jerusalem, Israel).

- No, (58. O., Curator, Communications Museum of Macao, China).

- Yes, 'The exhibit can cause frustration seldom shown on Thai faces' (60. M.B., Science Show and Exhibit Design Consultant, National Science Museum, Thailand).

(3) Europe

- Yes, (1. C.J., Science Communicator, UK).

- Yes, 'There are universal expressions linked to human emotions, but icons to represent these are subjective. I don't understand your point about the emotions triggered by exhibits (rather than representation of exhibits). I think these are different issues' (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).

- Yes, 'The discussion and display of emotions is viewed very differently in different parts of the world, in my experience, and so yes this must have an influence. The English, for example, traditionally do not like displaying their emotions or discussing them with strangers, and so this should be borne in mind when designing exhibits of this kind. Also, different sections of society will have differing reactions to physical sensations - the young will be more responsive, the elderly less so' (3. S.W, educator, Benjamin Franklin House, UK).


- Yes, (15. H.H., director, Pike Science Centre, Finland).

- Yes, (16. S.D., assistant to the management board, Deutsches Hygiene Museum Dresden, Germany).

- Yes, (17. P.S., director, Serlachius Museums, Finland).


- No, (24. A.C., project manager, Centre for Science Education

- Yes, 'see answer 9' (27. G., Sub-Director, mmaca Museu de Matemàtiques de Catalunya, Spain).

- No, (29, J.Š., Educator, iQpark, Czech Republic).

- Yes, (33. P.J., Exhibition Manager, Heureka, the Finnish Science Centre, Finland).

- No, 'I think that this question is difficult to see where you are going a little. As far as the colours go then in my experience as long as they are not too jarring or bright then most seem fine. I do believe that cultural difference will influence emotional reactions to things, but I do not think that in the case of colours this is not a massive factor’ (34. S.A., Educator, National Space Centre, UK)


- Yes, (41. J.A.A., Head of the Science Center, Oslo Science Center, Norway).

- Yes, (42. N.D., Coordinator of Science Exhibitions, Belgrade's Science festival and Science Park Belgrade, Serbia ).

- Yes, (43. M.B., Director of Media and Learning Center, Experimentarium, Denmark).

- No, (44. P.K., Director, AHHAA Science Centre, Estonia).

- Yes, (45. A.O., Director, Visindasmíðjan, Iceland).


- Yes, 'You can observe at exhibits, where visitors interact with robots (e.g. game-robot, ant-bots), that they humanize the robots, even industrial robots. To a certain extent this might be a consequence of the representation of robots in popular culture' (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).

- Yes, 'Yes but not so much with children, they seem to express themselves more openly' (53. S.P., Director, Observatory Science Centre, UK).


- No, 'Generally no, maybe just in some parts, in some special situations or for a short period of time’ (106. D.E., Head of Exhibitions and Publishing, Center for the Promotion of Science,
- Yes, ‘Don't understand this question. Happy to respond if I can get a clarification’ (111. C.L., Exhibitions Manager, Thinktank Birmingham Science Museum, UK).

- Yes, (112. I.F., Centro Ciência Viva de Bragança, Coordinator of explainers, Portugal).

- Yes, (113. N.V., Educator, Technotown, Italy).

- Yes, ‘We have used symbols without issue. I think your symbols are fairly universal’ (117. G.B., Curator, Tyne and Wear Archives & Museums, UK).


- Yes, ‘Culture is largely based on emotion. It would be good to stress that, in science, it’s actually okay to get things wrong - so long as something is learnt by it’ (121. M.S., Team Leader, Science Museum London, UK).

(4) Middle East


(5) North America


- Yes, ‘Yes and no - cultural differences influence the ability to interpret and read emotions and emotional reactions, which is different. The reaction is real - it’s the expression that gets interpreted’ (8. D.H., director, TELUS Spark, Canada).


- Yes, ‘The “excited” face above appears to me, to be shocked and/or surprised. The “doubtful” face appears to me, to moderately happy? More Language issues’ (12. Anonymous, curator, Kalamazoo Aviation History Museum, USA).

- Yes, 'I don't have a good example but we've seen parents from some cultures push their kids to get a "right answer" at an exhibit' (13. L.M., researcher, Arizona Science Center, USA).

- No, 'It is more likely that the mood or the emotions held by the person at a specific moment will affect the outcome, rather than a cultural shock' (14. Anonymous, educator, Planetario Alfa, Mexico).


- No, 'The user looks engaged in the activity. I can't tell what his emotional state is. The photo appears to be staged, so that doesn't make it a good test' (35. K.P. Director of Exhibit Services, Exploratorium, USA).


- Yes, (57. R.S., Executive Associate Director, Exploratorium, USA).


- Yes, (64. H.H., Director, Connecticut Science Center, USA).

- No, 'I'm sure there are differences, but I have not witnessed any in exhibits' (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).


- Yes, 'Many of our exhibits are a matter of understanding a concept to understand what the exhibit does, again is it just culture or is it the economic level and educational importance and social skills that cause some to abuse our exhibits while others don't' (67. G.B. Curator, SciTech Hands On Museum, USA).

- Yes, (69. S., Exhibit Developer, Creative Discovery Museum, USA).

- No, (72. Anonymous, Educator, Columbia Memorial Space Center, USA).

- Yes, (73. H.S., Director, Durango Discovery Museum, USA).

- Yes, 'How people react to things will depend on culture, age, gender, prior experiences, and much more but curiosity and the playfulness of humans is two of the major reasons we learn as much as we do and are genetically predisposed to do so' (74. E.M., Educator, Explora, USA).

- No, (76. Anonymous, Director, Museu Exploratório de Ciências -

- Yes, 'Different values can make different levels of emotional reactions' (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).

- Yes, (80. Anonymous, Education Manager/Staff Scientist, Connecticut Science Center, USA).

- Yes, (81. Anonymous, Director, Explora, USA).

- Yes, (82. J.J.R., Director, Science Museum of Minnesota, USA).


- Yes, (84. Anonymous, Educator, Sony Wonder Technology Lab, USA).


- No, 'If exploration is the point of the exhibit rather than getting something right or wrong, then learning about how one feels when they engage in a task would be interesting' (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, 'While facial expressions, like happy and sad, are almost universal, some expressions, such as fireworks or starbursts, may be unfamiliar to some as to what they are expressing' (87. D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, (88. S.R., Researcher, Lawrence Hall of Science, USA).


- Yes, (90. L.L., Director, Ocean Star Offshore Drilling Rig Museum: Offshore Energy Center, USA).


- Yes, (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).


- Yes, 'Emotion is attached to cultural behavior' (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).
- No, 'Facial expressions are often universal' (96. N.T., Director, Houston Museum of Natural Science: HMNS, USA).

- Yes, (97. Anonymous, Project Director of Exhibits and Programs, Sciencenter, USA).

- Yes, 'and again.....so what. The purpose of the exhibit is to engage people - even if that engagement takes the form of annoying them. The point is not to have everything so smoothed out as to never disturb anyone. BORING!' (98. C.M., CEO: Chief Executive Officer, Miami Science Museum, USA).

- Yes, 'I can accept that emotional triggers may be an influencing factor in the successful use of an exhibit, but I am not sure I fully understand this exhibit’s emotional triggers - why would a user feel one way or another about magnetism, or this exhibit’s design in particular?' (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).

- No, (103. D.R., Director, Fleischmann Planetarium and Science Center, USA).

- Yes, 'Colors stand for different emotions in different countries' (104. M.B., Researcher, The Franklin Institute, USA).


(6) Oceania

- No, 'I think the examples above are related to events and this is where their significance lives. When used out of context, such as colour they lose the significance. Just as lightening a candle in church is significant, but lighting a candle at night if there is no power is not' (5. S.S., curator, Exscite centre - Waikato Museum, New Zealand).


- No, (30. A.H., Director, Scitech, Australia).

- Yes, 'If a culture is more reserved in showing fear, embarrassment, happiness, etc. then it can impact on the visitor’s responses' (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

- Yes, (37. C.W., Exhibitor, Monash Science Centre, Australia).


- Yes, (61. A.B., Director, Scitech, Australia).

(7) Russia

- No, 'Science is multicultural and international. Cultural differences
and related emotions may only occur if you mix cultures. If you are having audience with the same acceptation - don't see any problem here' (119. I.K., Director, Experimentarium Science center, Russia).

(8) South America

- Yes, (68. A.C.P., Director, Espaço Ciência, Brazil).
- No, (70. F.A., Director, Centro interactivo de Ciencias - La Punta, Argentina).
- No, 'I believe that these issues are more general in the world' (75. M.K., Evansville, Former Director, Brazil).
- Yes, (79. V.P., Educator, Espacio Ciencia LATU, Uruguay).
- No, 'Can't come up with one example of such issue in our exhibits' (101. M.H., Designer, Ciencia Viva, Uruguay).
- Yes, (102. M.E.V., Educator, Museu de Astronomia e Ciências Afins: MAST, Brazil).
- Yes, 'Yes. They "touch" our perspective about others. They promote different experiences' (107. E.H., Director, Maloka, Colombia).
- Yes, (114. P.D.S., Director, Museo del Mar, Argentina).
- No, 'We believe that the visitors personality influences more his emotional reactions than the culture he or she belongs to' (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).
- No, (116. V.V., Educator, Museo Interactivo Mirador: MIM, Chile).

16. Age issues:
For example, England offers playgrounds in public parks for young children. It also discounts bus and railway tickets for old persons. Concerning the centrifuge exhibit, it may not be suitable for old visitors to sit down and rotate on it.

Do you believe that there are cultural concerns related to age issues?

Please explain your answer, if one of your exhibits shows this issue.

<table>
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<tr>
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<td>(1) Africa</td>
<td>- Yes, (100. J.J.A., Director, Ghana Planetarium Science Centre, Ghana).</td>
</tr>
<tr>
<td></td>
<td>- Yes, 'We a building site in the centre which adults can not engage</td>
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with as many of the walkways are too small' (105. M., Science Centre Manager, Sci-Bono Discovery Centre, South Africa).

- Yes, 'Yes of course' (109. A.Z., Director, Tunis Science City, Tunisia).

- No, (120. A.L., Educator, Cape Town Science Centre, South Africa).

(2) Asia

- No, 'Here it is the physical ability of a per which govern the act' (9. S.J.S., curator, Science City Kolkata, India).


- Yes, 'In our science for children gallery we have a corner for children below 8 years only. But parents always accompany them in that area. On the contrary they enjoy it in the company' (19. U.K., curator, Nehru Science Centre, India).

- Yes, (22. C.L., researcher, National Museum of Natural Science in Taiwan, China).

- No, (23. K.C.C., volunteer, National Museum of Natural Science in Taiwan, China).

- No, (36. A.C.J., Director, Science Discovery Center, Philippines).

- No, 'This may not be cultural but wherever they are, the exhibits will not be suitable for older visitors' (38. C.L.L., Evaluator, Science Centre Singapore, Singapore).

- Yes, 'I believe that there are exhibits that might not be suitable for older people. Although at our centre, we have not put up any sign to indicate so. We have a trampoline in our Kinetic Garden that is probably more suitable for the younger ones, but adults are free to try it if they wish' (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).

- Yes, 'Most old people accompanying their rather young wards to our science parks enjoy seeing the younger ones ride the exhibit than trying it themselves' (49. E.I., Director, Birla Industrial & Technological Museum: BITM, India).

- Yes, 'Some exhibits are not suitable for people with high blood pressure, pregnant women, or elderly, so taboo and notes need to be shown clearly with relevant exhibits' (50. Anonymous, Designer, China Science and Technology Museum, China).

- No, 'I am not aware of research on these areas. Again if cultural is defined within one culture, then there are age differences. As for age differences across countries I am not sure' (56. D.A.P., Curator, Bloomfield Science Museum Jerusalem, Israel).

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- Yes, (58. O., Curator, Communications Museum of Macao, China).


(3) Europe

- Yes, 'We find older visitors are less likely to join in interactive activities' (1. C.J., Science Communicator, UK).

- Yes, 'Attitudes to different age groups are different between cultures, but they are not necessarily fixed. E.g. what constitutes "old age" in the UK rises each year. My grandparents' generations were "old" in their 50's. My parents are not "old" in their 60's' (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).

- Yes, 'One's expectations, attitudes and interests change over the course of one's life, so yes I would say that a visitor's age greatly influences how they interact with exhibits. Our exhibits however are only used by school children so we do not have this problem' (3. S.W, educator, Benjamin Franklin House, UK).

- No, 'Don't quite understand' (4. D.S., Interpretation assistant, Glasgow Science Centre, UK).


- Yes, (15. H.H., director, Pike Science Centre, Finland).

- Yes, (16. S.D., assistant to the management board, Deutsches Hygiene Museum Dresden, Germany).

- Yes, (17. P.S., director, Serlachius Museums, Finland).


- Yes, (24. A.C., project manager, Centre for Science Education (CSE), Greece).

- No, 'Throughout all cultures that are specific activities that are for specific age ranges, not all activities can be inclusive to all ages. This is the same across all cultures' (25. Anonymous, Exhibit Manager, Eureka! The National Children's Museum, UK).

- Yes, 'Our exposition is mostly composed by hands on exhibits of mathematics. One of our slogan is: Touching is not forbidden. touching isn't a problem for young people, but older visitors must be convinced to manipulate exhibits. Consequently, other slogan of our exposition is: It's never too late to have a happy childhood' (27. G., Sub-Director, mmaca Museu de Matemàtiques de Catalunya, Spain).
- No, (29. J.Š., Educator, iQpark, Czech Republic).

- Yes, (33. P.J., Exhibition Manager, Heureka, the Finnish Science Centre, Finland).

- No, 'I think that regardless of culture it would be obvious whether you should or should not do an activity due to age or any other impairment' (34. S.A., Educator, National Space Centre, UK)

- Yes, 'I believe that some of our exhibits have print that is too small and too light-coloured to be easily read by older adults or those with visual problems' (39. D.K.M.G., Educator, Museo Galileo, Italy).

- No, (41. J.A.A., Head of the Science Center, Oslo Science Center, Norway).

- No, 'I think it is common for all people to sit in a chair, on a rock, or to rotate on something during their life (liana, swing). So it is the same thing in all cultures, and different approach due to age difference (that you mention) will be equally present in any country' (42. N.D., Coordinator of Science Exhibitions, Belgrade's Science festival and Science Park Belgrade, Serbia).

- Yes, (43. M.B., Director of Media and Learning Center, Experimentarium, Denmark).

- No, (44. P.K., Director, AHHAA Science Centre, Estonia).

- No, (45. A.O., Director, Visindasmíðjan, Iceland).


- Yes, 'According to my observations exhibits, which are not only hands-ons, but body-ons, where you have to use your whole body, like experiments concerning sports (e.g. the Batak Wall, where you have to push lighting up buttons on a wall in front of you very quick), are more frequented by children and teenager than by adults, especially elderly people. On the one hand in my opinion it results from cultural aspects, e.g. that it seems not so suitable for adults to jump around in the public; on the other hand I think it's not the cultural aspect alone, e.g. children have a bigger urge to move than elderly people' (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).

- Yes, 'There are but age often involves some impairment. Children hang upside down on our 'big lever', I'm not sure I would wish to' (53. S.P., Director, Observatory Science Centre, UK).

- No, 'No' (106. D.E., Head of Exhibitions and Publishing, Center for the Promotion of Science, Serbia).

- Yes, 'We have recently opened an outdoor area called the Science Garden. It has many bodies-on exhibits and some hands-on exhibits. Some are very difficult for young children to operate (e.g. a square wheel wagon 2 visitors can ride on and push themselves but because the wagon is heavy, they need to be very strong to get it moving) and need the help of able-bodied adults' (111. C.L., Exhibitions Manager, Thinktank Birmingham Science Museum, UK).

- No, (112. I.F., Centro Ciência Viva de Bragança, Coordinator of explainers, Portugal).

- Yes, (113. N.V., Educator, Technotown, Italy).

- Yes, 'I am not sure the problem is necessarily cultural maybe it is more related to the older generation feeling comfortable with new technologies' (117. G.B., Curator, Tyne and Wear Archives & Museums, UK).


- Yes, 'Only the physically active exhibits may deter the older generation, much as they would probably not use a slide in a playground. The elderly are as likely to use any other exhibits as much as anyone else' (121. M.S., Team Leader, Science Museum London, UK).

(4) Middle East


(5) North America


- Yes, 'I really don't understand why you would use "cultural" in this context - in fact in many of these examples you are really not describing "cultural" influences at all - at least not in the traditional sense. You are describing naive worldviews, physical and design affordances' (8. D.H., director, TELUS Spark, Canada).


- Yes, (12. Anonymous, curator, Kalamazoo Aviation History
- Yes, 'Probably different groups have different expectations for public behavior for different ages' (13. L.M., researcher, Arizona Science Center, USA).

- Yes, 'Some expositions are dangerous for younger or older people, so there must be a sign that warns people of any potential dangers related to age or illnesses' (14. Anonymous, educator, Planetario Alfa, Mexico).


- No, 'Certain things are designed for certain ages - this is universal between all cultures. Places that are experience with international audiences such as Disney have found ways to prompt visitors as to the safe use of the exhibits' (28. Anonymous, Exhibitor, Berkshire museum, USA).


- No, 'Older visitors have a greater life experience and are usually able to determine if an activity is appropriate for them' (35. K.P. Director of Exhibit Services, Exploratorium, USA).


- Yes, (57. R.S., Executive Associate Director, Exploratorium, USA).


- No, 'I think the main issue here is that of being old enough to "do" the exhibit and in good enough shape to stay on it' (63. D.J., Educator, Clark Planetarium, USA).

- Yes, (64. H.H., Director, Connecticut Science Center, USA).

- No, 'I concerns regarding age are similar in most cultures and that the concerns are more about physical safety than age' (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).

- Yes, ‘Yes, we have an outdoor exhibit that is geared towards everyone, some of our indoor exhibits are made specifically for children, we have a broadcast simulator which the adults of any age use. Exhibits that only children can use makes the older adults lose interest quickly’ (67. G.B. Curator, SciTech Hands On Museum, USA).

- No, (69. S., Exhibit Developer, Creative Discovery Museum, USA).

- Yes, (72. Anonymous, Educator, Columbia Memorial Space Center, USA).

- Yes, (73. H.S., Director, Durango Discovery Museum, USA).

- Yes, ‘Children are also more reckless, adults more reserved and worried about bodily harm. As much as young children cannot do some things the same applies for the elderly. They can read but need larger print size and better light. Hearing, flexibility and dexterity are a few of the other physical characteristics that are affected by age and should be thought about when designing activities for people to try’ (74. E.M., Educator, Explora, USA).

- No, (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).


- Yes, ‘If things were done in one way years ago, a person’s habits/understanding may be outdated’ (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).

- Yes, (80. Anonymous, Education Manager/Staff Scientist, Connecticut Science Center, USA).

- Yes, ‘At our center every person is not expected to use or be interested in every exhibit’ (81. Anonymous, Director, Explora, USA).

- No, ‘We make assumptions about what “older” visitors want and are able to do’ (82. J.J.R., Director, Science Museum of Minnesota, USA).


- No, ‘This is a question of age not culture’ (84. Anonymous, Educator, Sony Wonder Technology Lab, USA).


- No, ‘The exhibits can be made for handicapped to explore. But, as with everything, maybe no everyone could use it unless the design was changed to accommodate everyone. This is a design issue that
is easily remedied. It all depends on who the target audience is and the purpose of the exploration’ (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).

- No, ‘I think there are universal concerns, as older people tend not to interact with exhibits as much as younger people do, but I do not think the age issue is a cultural issue’ (87. D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

- No, (88. S.R., Researcher, Lawrence Hall of Science, USA).


- No, ‘I feel all cultures have similar concerns’ (90. L.L., Director, Ocean Star Offshore Drilling Rig Museum: Offshore Energy Center, USA).


- Yes, ‘In my experience, children are far more likely to be vigorously physical in exhibits. Also in my experience, if a child is interested in using an interactive exhibit, most adults will stop using the exhibit and will let the child use the exhibit’ (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).


- Yes, ‘All exhibits have an "age" component to it’ (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).

- No, ‘This seems more like a common sense concern’ (96. N.T., Director, Houston Museum of Natural Science: HMNS, USA).

- Yes, (97. Anonymous, Project Director of Exhibits and Programs, Sciencenter, USA).

- No, ‘really - this is now getting tedious. If someone feels uncomfortable sitting on the exhibit then they likely won't do it. You are trying to build a science center not a vanilla yogurt room’ (98. C.M., CEO: Chief Executive Officer, Miami Science Museum, USA).

- No, ‘We have an angular momentum exhibit that is similar - older visitors are not prone to use it but younger ones love it. So -- instead there may be intergenerational learning, for example a young person my be excited to try the centrifuge or angular momentum exhibit, but an older one can contribute, help explain it, or ask provocative questions of the younger visitor to get them to better consider the principal of the experience’ (99. S.D., Vice
President, Exhibition and Design, Mobius Science Center, USA).

- No, (103. D.R., Director, Fleischmann Planetarium and Science Center, USA).

- Yes, 'This is a delicate issue. We put a "disclaimer" on a tilted room exhibit saying that the experience could cause dizziness and confusion and then left it to people to decide if their own tendency to vertigo would cause this problem' (104. M.B., Researcher, The Franklin Institute, USA).

- Yes, 'There are several exhibits through the years that I have seen that we have a hard time trying to get adults to interact with because they are geared in one way or another toward children, whether it be the height, the physical stamina or ability. I believe that age does keep certain visitors from interacting with certain exhibits' (108. J.H., Director of Education, GWIZ - The Science Museum, USA).

(6) Oceania

- No, 'Here we use design to overcome issues in relation to the age of the audience. Size, Step high, location, look and feel to exclude differing ages' (5. S.S., curator, Exscite centre - Waikato Museum, New Zealand).

- Yes, 'Some exhibits have signs saying not suited to very young or elderly and infirm, e.g. swivel chair' (11. R.M., trustee, Exscite Science Centre - Waikato Museum, New Zealand).

- Yes, (30. A.H., Director, Scitech, Australia).

- Yes, 'On full body, highly immersive exhibits, older visitors may injure themselves. This is also true for exhibits that cause “unbalanced dizziness" in older visitors whose sense of balance is declining’ (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

- No, 'We encourage all ages, young and old to be inquisitive. Just because someone is numerically old, they should not stop challenging themselves and trying new things' (37. C.W., Exhibitor, Monash Science Centre, Australia).


- Yes, (61. A.B., Director, Scitech, Australia).

(7) Russia

- No, ‘Older people control themselves and understand that science center is more for kids then adults’ (119. I.K., Director, Experimentanium Science center, Russia).

(8) South America

- Yes, (68. A.C.P., Director, Espaço Ciência, Brazil).

- Yes, (70. F.A., Director, Centro interactivo de Ciencias - La Punta,
Argentina).

- Yes, 'Also, technological issues are to discourage older people' (71. C.A., Educator, Parque Explora Medellín, Colombia).

- Yes, 'We face exactly the same problem with the exhibits which are electronic games and simulations. The adults and old people don’t get the idea of the game, and how to manipulate the joysticks, but the children make it very easily' (75. M.K., Evansville, Former Director, Brazil).

- Yes, 'Older persons do not like the gyroscope' (79. V.P., Educator, Espacio Ciencia LATU, Uruguay).

- Yes, 'Some exhibits involve physical activities not suitable for any age: use of force, having to kneel or spin or balance' (101. M.H., Designer, Ciencia Viva, Uruguay).

- Yes, 'Some apparatus are dangerous for old people' (102. M.E.V., Educator, Museu de Astronomia e Ciências Afins: MAST, Brazil).

- Yes, 'But we have to accept them...' (107. E.H., Director, Maloka, Colombia).

- No, (114. P.D.S., Director, Museo del Mar, Argentina).

- No, 'In our museum we have many exhibits that we designed for small children or for young people, and some for all public, clearly each person knows his limits, even though our intention is for all the molecules to be for all public it can't always be this way, so we use graphics informations to indicate age, size, and weight limits' (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).

- No, (116. V.V., Educator, Museo Interactivo Mirador: MIM, Chile).

17. Gender issues:
Viewing the bicycle generator exhibit, most Thai girls wearing skirts would feel uncomfortable using it. Do you believe that cultural issues involve gender issues?

Please explain your answer, if one of your exhibits shows this issue.

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<td>- Yes, (100. J.J.A., Director, Ghana Planetarium Science Centre, Ghana).</td>
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<tr>
<td></td>
<td>- Yes, 'Once again I revert to our science of soccer exhibition. For some girls, soccer is seen as a male dominated sport and they therefore feel uncomfortable to engage with this exhibit' (105. M., Science Centre Manager, Sci-Bono Discovery Centre, South Africa).</td>
</tr>
</tbody>
</table>
- Yes, ‘Yes I do believe it’ (109. A.Z., Director, Tunis Science City, Tunisia).
- Yes, (120. A.L., Educator, Cape Town Science Centre, South Africa).

(2) Asia

- Yes, ‘Yes absolutely. This I have observed in exhibits as well as activities. In sit and draw contest girls wearing skirts are always uncomfortable as we ask them to sit and draw. I personally feel Many of them specially grown up do not come next time’ (19. U.K., curator, Nehru Science Centre, India).
- Yes, (22. C.L., researcher, National Museum of Natural Science in Taiwan, China).
- No, (23. K.C.C., volunteer, National Museum of Natural Science in Taiwan, China).
- Yes, ‘Cultural dress or wardrobe commonly used by the majority will have an effect on the use of the exhibit’ (36. A.C.J., Director, Science Discovery Center, Philippines).
- No, (38. C.L.L., Evaluator, Science Centre Singapore, Singapore).
- No, ‘Currently we do not design exhibits taking into account different gender use’ (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).
- Yes, ‘I believe it does, but not with the young ones’ (49. E.I., Director, Birla Industrial & Technological Museum: BITM, India).
- No, ‘This generator dose not refer to any specific science or technology area, it can be change to other operating form as it just shows how to turn kinetic energy into electrical energy. (If Thai girls never ride bicycle, this social/cultural issue should be considered). If it has to be bicycle generator, audience need solve their personal difficulties’ (50. Anonymous, Designer, China Science and Technology Museum, China).
- No, ‘I assume there are many differences within one culture, some girls using skirts and other trousers. if you want to address minorities then you have to follow universal design in order to include different populations’ (56. D.A.P., Curator, Bloomfield Science Museum Jerusalem, Israel).
- No, (58. O., Curator, Communications Museum of Macao, China).
- Yes, 'In a multitude of ways, girls have a differ approach to exhibits compared to boys' (60. M.B., Science Show and Exhibit Design Consultant, National Science Museum, Thailand).

(3) Europe

- Yes, (1. C.J., Science Communicator, UK).

- Yes, (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).

- Yes, (3. S.W, educator, Benjamin Franklin House, UK).

- Yes, 'The clothing of visitors of all cultures has a huge impact on exhibit design. Face-morphing exhibits are inappropriate for visitors wearing burqas, for example' (4. D.S., Interpretation assistant, Glasgow Science Centre, UK).


- Yes, (15. H.H., director, Pike Science Centre, Finland).

- Yes, (16. S.D., assistant to the management board, Deutsches Hygiene Museum Dresden, Germany).

- Yes, (17. P.S., director, Serlachius Museums, Finland).


- Yes, (24. A.C., project manager, Centre for Science Education (CSE), Greece).


- Yes, 'Usually, a competitive way to develop an activity causes a non-acceptance by female public. We try that our challenges procure a collaborative and not competitive dynamic' (27. G., Sub-Director, mmaca Museu de Matemàtiques de Catalunya, Spain).

- No, (29. J.Š., Educator, iQpark, Czech Republic).

- Yes, (33. P.J., Exhibition Manager, Heureka, the Finnish Science Centre, Finland).

- No, 'I think that any girl wearing a skirt would be uncomfortable using it, and that this issue is more a gender issue than a cultural one' (34. S.A., Educator, National Space Centre, UK)


- Yes, (41. J.A.A., Head of the Science Center, Oslo Science
- Yes, (42. N.D., Coordinator of Science Exhibitions, Belgrade's Science festival and Science Park Belgrade, Serbia).

- Yes, (43. M.B., Director of Media and Learning Center, Experimentarium, Denmark).

- No, (44. P.K., Director, AHHAA Science Centre, Estonia).

- Yes, (45. A.O., Director, Visindasmiðjan, Iceland).

- Yes, 'Same same and most "toys" we have are very appealing for male visitors, females have their own favorite’ (46. L.H., Educator, Science Centre Delft: TUDelft, Netherlands).


- Yes, 'One part of our experimental areas is a laboratory, where scientific workshops for children and teenager are offered. In workshops for boys and girls, often boys are dominant and pretend to be technical experts, although often they aren't. Thereby girls are restraint to participate and to express their ideas, even if their ideas are better than the ideas of the boys. Therefore we offer also some workshops for girls only. In these workshops we also can show an interest in the different interests of boys and girls: Boys often are interested in the technology by itself, whereas girls often want to know more about social aspects of technology (e.g. How can we use renewable energies?)' (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).

- Yes, 'Boys certainly seem more competetive but less contemplative with some exhibits. We prefer to use hand powered generators to allow access to a wider range of users' (53. S.P., Director, Observatory Science Centre, UK).


- No, 'Not only them, that could be uncomfortable for many different people' (106. D.E., Head of Exhibitions and Publishing, Center for the Promotion of Science, Serbia).

- Yes, (111. C.L., Exhibitions Manager, Thinktank Birmingham Science Museum, UK).

- No, (112. I.F., Centro Ciência Viva de Bragança, Coordinator of explainers, Portugal).

- Yes, (113. N.V., Educator, Technotown, Italy).

- Yes, 'We have had bicycle based interactives on the gallery but have never thought to investigate if visitors wering a skirt avoid using the exhibit' (117. G.B., Curator, Tyne and Wear Archives &

- Yes, ‘We get round this by having two sets of bikes, one of which is much more upright and would therefore avoid this issue’ (121. M.S., Team Leader, Science Museum London, UK).

(4) Middle East


(5) North America


- Yes, ‘Different cultures do have different perspectives on gender issues and different influences on behaviour’ (8. D.H., director, TELUS Spark, Canada).


- Yes, ‘Lots of research shows this exists. Trying things out, engaging in competition, technical content, all seem to engage gender issues’ (13. L.M., researcher, Arizona Science Center, USA).

- Yes, ‘Since not all the countries hold the same cultural view, the success of the exposition will be determined by the cultural similarities of the exposition itself’ (14. Anonymous, educator, Planetario Alfa, Mexico).


- Yes, ‘If a person feels unduly exposed, then they will not use the exhibit’ (35. K.P. Director of Exhibit Services, Exploratorium, USA).


- Yes, (57. R.S., Executive Associate Director, Exploratorium, USA).

- Yes, (59. A.G., Designer, Cape Fear Museum of History and
- No, 'I think this would apply to any girls or women wearing skirts. I would also think a gentleman in a kilt would feel uncomfortable' (62. R.L.F., Director, Clay Center for the Arts & Sciences, USA).


- Yes, (64. H.H., Director, Connecticut Science Center, USA).

- Yes, 'Yes, I think there are differences. In the U.S. we try to allow experiences that can be used in different ways to allow for different abilities--for example, in addition to a bicycle pedaled with one's feet, could there also be a version where one could use one's hands to turn it?' (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).

- Yes, 'We experience this with Muslim visitors on a number of exhibits' (66. L.C., Exhibitor, The Tech Museum, USA).

- Yes, 'We have Muslim female visitors that will not touch anything, because it is considered "wrong" for a woman to enjoy herself, she is there for her children' (67. G.B. Curator, SciTech Hands On Museum, USA).

- Yes, 'I think it more had to do with how socially and culturally boys and girls are viewed and how this effects their understanding and access to science' (69. S., Exhibit Developer, Creative Discovery Museum, USA).

- Yes, (72. Anonymous, Educator, Columbia Memorial Space Center, USA).

- Yes, (73. H.S., Director, Durango Discovery Museum, USA).

- Yes, 'Would those girls feel uncomfortable using it or uncomfortable using it when they can be seen by men? Culture does influence gender behavior not physical capabilities. If you want both genders to have the same opportunities to investigate phenomenon then what do you have to do to enable them to do so?' (74. E.M., Educator, Explora, USA).

- Yes, (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).


- Yes, 'Different societies would have different values. This also affects how a person perceives the directions' (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).

- Yes, (80. Anonymous, Education Manager/Staff Scientist, Connecticut Science Center, USA).

- Yes, (81. Anonymous, Director, Explora, USA).
- Yes, 'Many women ride bikes wearing skirts I think that women would not experience this exhibit if they were wearing a skirt - I do believe that gender and culture are linked' (82. J.J.R., Director, Science Museum of Minnesota, USA).


- Yes, 'You need to consider gender, religion, culture and simply clothing constraints of varied peoples when designing any physical interactive' (84. Anonymous, Educator, Sony Wonder Technology Lab, USA).


- No, 'Again, this is a design issue that can probably be solved with perhaps some angling of the seat so that the skirt stays down' (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, 'Clothing issues, such as skirts, or full body garments such as Muslim hijab, may make physical involvement in certain exhibits awkward. But I think the bigger issue for gender bias is whether females feel familiar with or approachable with technology exhibits. Also some cultures suppress what females should have access to' (87. D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, (88. S.R., Researcher, Lawrence Hall of Science, USA).


- Yes, (90. L.L., Director, Ocean Star Offshore Drilling Rig Museum: Offshore Energy Center, USA).


- Yes, 'Gender issues aren’t just about clothing (as I’m sure you know). Our society marks many things as being “for girls” and “for boys”. In science museums, often the “boy” things are standard, and “girl” things are often seen as frivolous at best, and as things that would be turn-offs for boys at worst. (no one seems to worry too much about things that are turn-offs for girls)' (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).


- Yes, 'We generally have conservative exhibits' (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).
- No, 'Once again, exhibit design. Why not have a peddle attached to a wheel (like an old sewing machine) that could produce the same result without having to have the girl sit in a skirt?' (96. N.T., Director, Houston Museum of Natural Science: HMNS, USA).

- Yes, (97. Anonymous, Project Director of Exhibits and Programs, Sciencenter, USA).

- Yes, 'So what - they can do the things they are comfortable with or have a cross cultural experience' (98. C.M., CEO: Chief Executive Officer, Miami Science Museum, USA).

- Yes, 'If comfort is a challenge to a portion of the population then design staff should seek to address this need - in the case of the bicycle generator the exhibit can be conceived in a way that by raising the height of the seat a woman wearing a skirt would not be uncomfortable' (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).

- Yes, (103. D.R., Director, Fleischmann Planetarium and Science Center, USA).

- Yes, 'Often examples of the application of science principles are biased toward males (e.g. examples from competitive sports). It is important to use examples to which that both genders can relate' (104. M.B., Researcher, The Franklin Institute, USA).


(6) Oceania

- Yes, 'For example when looking at a new exhibition around taking photos of faces we would consider how this exhibit works for visitors who are women of the Muslim faith, wearing headscarves and other visitors who may not want their photo taken for various reasons' (5. S.S., curator, Exscite centre - Waikato Museum, New Zealand).


- Yes, (30. A.H., Director, Scitech, Australia).

- Yes, 'For full body immersive exhibits, we have overalls for visitors to put on over their own clothes. This may be uncomfortable for visitors who do not wish to be seen in trouser legs, but allows them to use an exhibit if they don't mind wearing overalls. Similarly, neck ties, loose long hair and headscarves may create safety issues if they get caught in moving parts up in' (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

- Yes, 'We try and push gender stereotypes by showing both male and female scientists and researchers' (37. C.W., Exhibitor, Monash Science Centre, Australia).
- Yes, (61. A.B., Director, Scitech, Australia).

(7) Russia
- No, (119. I.K., Director, Experimentanium Science center, Russia).
- Yes, (68. A.C.P., Director, Espaço Ciência, Brazil).
- Yes, (70. F.A., Director, Centro interactivo de Ciencias - La Punta, Argentina).
- Yes, 'Similar issues can happen in game design, soccer, etc... ' (75. M.K., Evansville, Former Director, Brazil).
- No, (79. V.P., Educator, Espacio Ciencia LATU, Uruguay).
- No, 'Can't come up with one example of such issue in our exhibits. There is no mandatory use of skirts for schoolgirls in our country' (101. M.H., Designer, Ciencia Viva, Uruguay).
- Yes, 'In Brazil girls go to school using trousers' (102. M.E.V., Educator, Museu de Astronomia e Ciências Afins: MAST, Brazil).
- Yes, 'Those are ones of the most important and powerful topics. Gender, science and society' (107. E.H., Director, Maloka, Colombia).
- Yes, (114. P.D.S., Director, Museo del Mar, Argentina).
- Yes, 'Maybe in other cultures it is more noticable but in our country there are not that many differences' (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).
- No, (116. V.V., Educator, Museo Interactivo Mirador: MIM, Chile).

(8) South America

18. Disabled people:
In the UK considerable effort is made to allow access by disabled people. Three steps have to be climbed to use the speaking dishes exhibit. Do you believe that cultural considerations affect the use of interactive exhibits by disabled people?

Please explain your answer, if one of your exhibits shows this issue.

<table>
<thead>
<tr>
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<td>- Yes, (100. J.J.A., Director, Ghana Planetarium Science Centre, Ghana).</td>
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</tbody>
</table>
- ‘Yes, Very few of our exhibits are designed for blind people to use. Some of our exhibits are also too high for people in wheelchairs to use’ (105. M., Science Centre Manager, Sci-Bono Discovery Centre, South Africa).

- ‘Yes, Yes of course’ (109. A.Z., Director, Tunis Science City, Tunisia).

- Yes, (120. A.L., Educator, Cape Town Science Centre, South Africa).

(2) Asia

- No, (9. S.J.S., curator, Science City Kolkata, India).


- No, ‘It is not cultural issue but failure of designer and architecture also’ (19. U.K., curator, Nehru Science Centre, India).

- Yes, (22. C.L., researcher, National Museum of Natural Science in Taiwan, China).

- No, (23. K.C.C., volunteer, National Museum of Natural Science in Taiwan, China).

- No, (36. A.C.J., Director, Science Discovery Center, Philippines).

- Yes, (38. C.L.L., Evaluator, Science Centre Singapore, Singapore).

- Yes, ‘We have a similar exhibit which does not have handicap access. But in recent years the focus on access for disabled people has increased. If I build a new exhibit, I am expected to provide handicap access if possible’ (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).

- Yes, ‘Provisioning for disabled physical access to all exhibits and cognitive access to their contents is often logistically and economically very difficult to achieve’ (49. E.I., Director, Birla Industrial & Technological Museum: BITM, India).

- Yes, ‘Developed societies are people-oriented, we should consider disability needs, the example exhibit shown above should have wheelchair path’ (50. Anonymous, Designer, China Science and Technology Museum, China).

- No, ‘I assume there are many differences within one culture. If you want to address minorities then you have to follow universal design in order to include different disabled populations’ (56. D.A.P., Curator, Bloomfield Science Museum Jerusalem, Israel).

- Yes, (58. O., Curator, Communications Museum of Macao, China).

- Yes, ‘Many countries give little attention to problems of disabled people as the exhibit illustrates’ (60. M.B., Science Show and
(3) Europe

- Yes, (1. C.J., Science Communicator, UK).

- Yes, 'Most societies have a long way to go to achieve true equality (including the UK) but some are more advanced on this path than others' (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).

- Yes, 'Our culture in the UK is improving with regard to provisions for disabled people, though I can imagine that this is not the case in all countries. The ideal would be to make all your exhibits accessible to people of all abilities' (3. S.W, educator, Benjamin Franklin House, UK).

- No, (4. D.S., Interpretation assistant, Glasgow Science Centre, UK).


- Yes, (15. H.H., director, Pike Science Centre, Finland).

- Yes, (16. S.D., assistant to the management board, Deutsches Hygiene Museum Dresden, Germany).

- No, (17. P.S., director, Serlachius Museums, Finland).


- Yes, (24. A.C., project manager, Centre for Science Education (CSE), Greece).


- Yes, 'An exhibition must be so rich to allow that disabled people can find an access to some of the exhibits. Design exhibits thinking about disabilities improves quality of materials (and people)’ (27. G., Sub-Director, mmaca Museu de Matemàtiques de Catalunya, Spain).

- Yes, (29. J.Š., Educator, iQpark, Czech Republic).

- Yes, (33. P.J., Exhibition Manager, Heureka, the Finnish Science Centre, Finland).

- Yes, (34. S.A., Educator, National Space Centre, UK)

- Yes, 'Those in need of a very heavy, electric type wheelchair cannot access the museum's first floor because the lift for the stairs cannot handle the weight to take the person to the appropriate elevator that actually accesses the first floor. This is a shame since
the first floor contains the museum’s most important pieces of Galileo. Many efforts have been made to help visitors with all types of disabilities, including a free guided visit to non-seeing visitors and free access to the person and their comnpaignon’ (39. D.K.M.G., Educator, Museo Galileo, Italy).

- No, (41. J.A.A., Head of the Science Center, Oslo Science Center, Norway).

- No, 'If you have obstacle to use exhibit it is a problem for all disabled people. I think that this is a question of bad design' (42. N.D., Coordinator of Science Exhibitions, Belgrade’s Science festival and Science Park Belgrade, Serbia).

- Yes, (43. M.B., Director of Media and Learning Center, Experimentarium, Denmark).

- No, (44. P.K., Director, AHHAA Science Centre, Estonia).

- No, (45. A.O., Director, Visindasmíðjan, Iceland).

- No, 'This we always try to do, but sometimes cannot be achieved' (46. L.H., Educator, Science Centre Delft: TUDelft, Netherlands).


- Yes, 'In the process of designing our exhibits, we thoroughly discuss e.g. the height of the pedestals of the exhibits, what is not only important to allow access to disabled persons, but also to children. Or we place chairs in front of some of the experiments, e.g. the robot, with whom you can play a game, what is helpful for elderly people. When the building of our museum was planned, some of the areas, which are now exhibition space, weren’t planned as exhibition space and therefore aren’t easily accessible by elevator. In that case accessibility can not only be allowed by technical means, but also by the help of our staff (e.g. our scientific explainers)' (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).

- Yes, 'There does seem to be a lack of awareness in many countries, but there are issues in making everything accessible' (53. S.P., Director, Observatory Science Centre, UK).


- No, 'No' (106. D.E., Head of Exhibitions and Publishing, Center for the Promotion of Science, Serbia).

- Yes, 'Don't understand this question. Happy to respond if I can get a clarification' (111. C.L., Exhibitions Manager, Thinktank Birmingham Science Museum, UK).

- Yes, (112. I.F., Centro Ciência Viva de Bragança, Coordinator of
explainers, Portugal).

- Yes, (113. N.V., Educator, Technotown, Italy).

- No, (117. G.B., Curator, Tyne and Wear Archives & Museums, UK).

- Yes, 'We would always make sure that exhibits are as accessible as possible for all users, including those who are disabled' (118. Anonymous, Educator, Enginuity - The Ironbridge Gorge Museum, UK).

- Yes, 'Steps automatically make an exhibit inaccessible to the disabled. Do you have to have steps? You'd also need to produce a document to outline in advance which exhibits would not be accessible' (121. M.S., Team Leader, Science Museum London, UK).

(4) Middle East


(5) North America

- No, (7. Anonymous, interpretation specialist, National Parks and National Historic Sites, Canada).


- Yes, 'The Museum tries to meet and surpass accessibility standards. A few years ago, we developed the Braille exhibition and worked in close partnership with the Canada National Institution for the Blind to help develop content, design and interpret the exhibition' (10. A.J., educator, Canada Science and Technology Museum, Canada).

- Yes, 'We try to construct legal wheelchair ramps wherever possible, however, the amusement rides make this impossible in some cases' (12. Anonymous, curator, Kalamazoo Aviation History Museum, USA).

- Yes, 'Disabled people identify with their families not other disabled people necessarily, so whatever cultural issues exist for the family exists for them' (13. L.M., researcher, Arizona Science Center, USA).

- Yes, 'If the exhibit is friendly for disabled people, it is more likely to be visited by a bigger number of people' (14. Anonymous, educator, Planetario Alfa, Mexico).

- Yes, 'It is crucial that the artifacts are not altered to increase accessibility if doing so would fundamentally change the work. Making a ramp so more could use this display is not a problem BUT modifying the dish might be. It is important to recognize that every
one of us has some kind of disability or ability that shapes our perceptions. Striving for homogeneity often results in failure for all’ (21. D.D., curator, MIT Museum, USA).

- Yes, 'It is based on a certain cultures awareness and conscious choice to include those with difference’ (28. Anonymous, Exhibitor, Berkshire museum, USA).


- No, 'No - this is just poor planning and allowing the design to take precedence over function. That said, not ever exhibit can be made universally accessible. It is important to have a variety of experiences that will cover the most conditions’ (35. K.P. Director of Exhibit Services, Exploratorium, USA).


- Yes, (57. R.S., Executive Associate Director, Exploratorium, USA).


- No, (63. D.J., Educator, Clark Planetarium, USA).

- Yes, (64. H.H., Director, Connecticut Science Center, USA).

- Yes, ‘Same as above. Yes, exhibits should be designed to be accessible by visitors with varying types of abilities. Ideally, the dishes would be lowered so that they are accessible to those in wheel chairs, children, and adults’ (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).


- Yes, 'Because we are hands on, the exhibits are made for those that can stand and sit on their own, there is no wheelchair access to a majority of our exhibits’ (67. G.B. Curator, SciTech Hands On Museum, USA).

- Yes, 'In the US, laws are in place to allow access for people with different types of disabilities, especially physical disabilities. It is called the American Disabilities Act. In exhibit design we use measurements for accessibility dictated from this law' (69. S., Exhibit Developer, Creative Discovery Museum, USA).

- Yes, (72. Anonymous, Educator, Columbia Memorial Space
- Yes, (73. H.S., Director, Durango Discovery Museum, USA).

- Yes, 'Developing activities and spaces for all or most people to be able to scientifically investigate concepts is a demanding but rewarding endeavor' (74. E.M., Educator, Explora, USA).

- Yes, (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).


- Yes, 'Some cultures develop access for disabled people more than others. This is not so much based on cultural values but monetary issues' (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).

- Yes, (80. Anonymous, Education Manager/Staff Scientist, Connecticut Science Center, USA).

- Yes, (81. Anonymous, Director, Explora, USA).

- Yes, 'The exhibit pictured is not accessible for a person in a wheelchair- clearly disabled people were not considered in the design of this exhibition- the culture of the disabled community is not considered- part of their cultural experience is their level of access or ability to participate in ALL exhibits’ (82. J.J.R., Director, Science Museum of Minnesota, USA).


- No, 'This question doesn't make much sense- isn't the issue whether one is being sensitive to people with Special Needs...?' (84. Anonymous, Educator, Sony Wonder Technology Lab, USA).


- Yes, 'We make every effort to make our exhibits accessible to disabled. We have those dishes; however, they are located on our shell drive, and foot level so everyone can walk up to them. Having them up on a platform can be solved by building a ramp up to the dish that wheelchairs and those who cannot climb steps can use' (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, 'Designers must be very conscious of designing exhibits to be accessible for many disabilities' (87. D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, (88. S.R., Researcher, Lawrence Hall of Science, USA).

- Yes, ‘Americans with Disabilities Act governs this idea and guides all construction and exhibit design for accessibility’ (90. L.L., Director, Ocean Star Offshore Drilling Rig Museum: Offshore Energy Center, USA).


- Yes, ‘We try really hard to make things accessible. Right now we’re working on an exhibition ABOUT assistive technologies for people with disabilities, so for that one in particular we’re taking extra steps to make sure that the exhibits are as usable as possible for people with both mobility disabilities and with sensory disabilities’ (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).


- No, ‘I believe disabled people just want to interact’ (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).

- Yes, ‘However... this could be made accessible...’ (96. N.T., Director, Houston Museum of Natural Science: HMNS, USA).

- Yes, (97. Anonymous, Project Director of Exhibits and Programs, Sciencenter, USA).

- No, ‘Culture has little to do with this - it is simply a matter of access’ (98. C.M., CEO: Chief Executive Officer, Miami Science Museum, USA).

- Yes, ‘Every effort to design exhibits in a way that makes them accessible to all should be of the highest priority. It is well understood in the design community that improving accessibility serves not just persons with particular challenges but usually works to improve the experience for all potential users’ (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).

- Yes, (103. D.R., Director, Fleischmann Planetarium and Science Center, USA).

- Yes, ‘Here I think it’s more a question of physical conditions than cultural considerations. Again, it's important to consider the accessibility of exhibits for people who are physically challenged. We would have a ramp up to this exhibit’ (104. M.B., Researcher, The Franklin Institute, USA).


(6) Oceania

- No, (5. S.S., curator, Exscite centre - Waikato Museum, New
- Yes, 'Not all are designed for disabled access' (11. R.M., trustee, Exscite Science Centre - Waikato Museum, New Zealand).

- Yes, (30. A.H., Director, Scitech, Australia).

- Yes, 'Sometimes it's unfeasible to cater to all visitors within an exhibit. In particular, a recent exhibition contained audio-language illusions within a multimedia exhibit. If it had been subtitled for hearing impaired visitors, it would have completely undermined the point of the exhibit for hearing-able visitors' (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

- Yes, (37. C.W., Exhibitor, Monash Science Centre, Australia).


- Yes, (61. A.B., Director, Scitech, Australia).

(7) Russia

- No, 'It's only a technical issue to make usable for disabled' (119. I.K., Director, Experimentanium Science center, Russia).

(8) South America

- Yes, (68. A.C.P., Director, Espaço Ciência, Brazil).

- No, (70. F.A., Director, Centro interactivo de Ciencias - La Punta, Argentina).


- Yes, 'This is an important point, because we usually work with some perceptions, directly related with disabilities' (75. M.K., Evansville, Former Director, Brazil).

- Yes, 'We have some old exhibits that are not accessible for people with physical disabilities. On the other side most people with mental disabilities enjoy the visit very much' (79. V.P., Educator, Espacio Ciencia LATU, Uruguay).

- Yes, 'Not always easy to overcome. But in our case we are working hard to that end. Last year a third of our exhibits were adapted for blind and deaf visitors. Next year we will made them accessible for people in wheelchairs' (101. M.H., Designer, Ciencia Viva, Uruguay).

- No, 'What I think is that there are countries more conscious about the issue of disabled people than others. In Brazil we are in the beginning to attend disabled people with' (102. M.E.V., Educator, Museu de Astronomia e Ciências Afins: MAST, Brazil).

- Yes, 'Disabled people are of course, part of our culture with different approaches about themselves' (107. E.H., Director, Maloka,
Colombia).

- Yes, (114. P.D.S., Director, Museo del Mar, Argentina).

- Yes, 'There’re cultures that work constantly to include disabled people, and the permit more accessibility to the exhibits, in our case we are culturally in debt with disabled people' (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).

- Yes, (116. V.V., Educator, Museo Interactivo Mirador: MIM, Chile).

19. Do you believe these 10 dimensions of cultural issues can affect any of these exhibits by more than one dimension or not?

Please give your reason for answer.

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<td>- Yes, (120. A.L., Educator, Cape Town Science Centre, South Africa).</td>
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<tr>
<td>(2) Asia</td>
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<tr>
<td>- Yes, 'Signages, languages, postures related to culture' (9. S.J.S., curator, Science City Kolkata, India).</td>
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<td>- Yes, (22. C.L., researcher, National Museum of Natural Science in Taiwan, China).</td>
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<td>- No, (23. K.C.C., volunteer, National Museum of Natural Science in Taiwan, China).</td>
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<td>- Yes, 'Definitely. A mix of more than one dimension especially in the country where I live can affect the exhibit. i.e. Age, disability and gender combined' (36. A.C.J., Director, Science Discovery Center, Philippines).</td>
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<tr>
<td>- Yes, (38. C.L.L., Evaluator, Science Centre Singapore, Singapore)</td>
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<tr>
<td>- Yes, (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).</td>
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</table>
- Yes, ‘All of these cultural considerations can potentially alter the way these mentioned exhibits are intended to communicate their underlying ideas to the visitors’ (49. E.I., Director, Birla Industrial & Technological Museum: BITM, India).

- Yes, ‘Exhibition design must consider these issues to achieve true people oriented’ (50. Anonymous, Designer, China Science and Technology Museum, China).


- Yes, (58. O., Curator, Communications Museum of Macao, China).

- Yes, ‘There are many dimensions of cultural difference many are cerebral so are not seen’ (60. M.B., Science Show and Exhibit Design Consultant, National Science Museum, Thailand).

(3) Europe

- No, ‘I'm sorry but this is a very difficult to understand question. I am not sure what you are asking' (1. C.J., Science Communicator, UK).

- No, ‘I don't understand what you are asking’ (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).

- No, ‘I'm afraid I don't understand this question. In my experience, language, social, and technological issues have the greatest impact on a person's ability to interact and successfully use an interactive exhibit’ (3. S.W, educator, Benjamin Franklin House, UK).


- Yes, (15. H.H., director, Pike Science Centre, Finland).

- Yes, (16. S.D., assistant to the management board, Deutsches Hygiene Museum Dresden, Germany).

- Yes, (17. P.S., director, Serlachius Museums, Finland).


- Yes, (24. A.C., project manager, Centre for Science Education (CSE), Greece).


- No, (27. G., Sub-Director, mmaca Museu de Matemàtiques de Catalunya, Spain).
- No, (29. J.Š., Educator, iQpark, Czech Republic).

- Yes, 'I would say that the joint effects of these factors or different subsortiments of the factors can and will affect the use and understanding of the exhibits' (33. P.J., Exhibition Manager, Heureka, the Finnish Science Centre, Finland).

- Yes, 'string theory' (34. S.A., Educator, National Space Centre, UK)


- Yes, (41. J.A.A., Head of the Science Center, Oslo Science Center, Norway).

- Yes, 'It is good to take into account as many factors as you can. Personally I think the cultural issues are not essential for this kind of exhibits' (42. N.D., Coordinator of Science Exhibitions, Belgrade's Science festival and Science Park Belgrade, Serbia).

- Yes, (43. M.B., Director of Media and Learning Center, Experimentarium, Denmark).

- Yes, (44. P.K., Director, AHHAA Science Centre, Estonia).

- Yes, (45. A.O., Director, Vísindasmiðjan, Iceland).

- Yes, 'The domain is in our country defined as esp. suited for beta-minded males...we fight it every day' (46. L.H., Educator, Science Centre Delft: TUDelft, Netherlands).


- Yes, 'In my opinion all these cultural aspects can affect the exhibits, because every potential user of interactive science exhibits is more or less influenced by previous knowledge deriving from their socialization into certain cultural groups: e.g. she or he is part of a distinct technological, language or visual culture etc. and all different types of knowledge deriving from this affect her or his activity with the exhibit' (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).

- Yes, (53. S.P., Director, Observatory Science Centre, UK).


- Yes, 'And it depends on person to person' (111. C.L., Exhibitions
- Yes, (112. I.F., Centro Ciência Viva de Bragança, Coordinator of explainers, Portugal).

- Yes, (113. N.V., Educator, Technotown, Italy).


- Yes, 'Exhibits are designed to be accessible for all users' (118. Anonymous, Educator, Enginuity - The Ironbridge Gorge Museum, UK).

- Yes, 'There are several different ways of looking at any exhibit, and several different visitor groups to do that looking' (121. M.S., Team Leader, Science Museum London, UK).

(4) Middle East


(5) North America


- Yes, 'Gender/language Language/concepts Social/age all are interconnected' (13. L.M., researcher, Arizona Science Center, USA).

- Yes, 'In order to make an exposition a hit, the cultural issues of the exposition should be evaluated to help determine the success it would represent' (14. Anonymous, educator, Planetario Alfa, Mexico).


- Yes, 'This question is not very clear. It is possible that an exhibit can be affected by more than one dimension' (35. K.P., Director of Exhibit Services, Exploratorium, USA).

- Yes, 'Language issues can always be combined with any of the other cultural issues' (51. M. Bilingual Evaluation Assistant, Oregon Museum of Science and Industry: OMSI, USA).

- Yes, (57. R.S., Executive Associate Director, Exploratorium, USA).


- Yes, 'I think much of it would have to do with language and translation' (62. R.L.F., Director, Clay Center for the Arts & Sciences, USA).

- Yes, 'I'm not sure I am understanding your question correctly, but I do believe that it is possible (even likely) to have multiple barriers/issues to visitor participation. Language, technology and conceptual understanding often overlap to create such barriers in the US.' (63. D.J., Educator, Clark Planetarium, USA).

- Yes, 'Simply being from a different culture and disabled as well could result in several dimensions being involved' (64. H.H., Director, Connecticut Science Center, USA).

- Yes, (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).


- Yes, 'Unfortunately, not everyone can be pleased' (67. G.B. Curator, SciTech Hands On Museum, USA).

- Yes, (69. S., Exhibit Developer, Creative Discovery Museum, USA).

- Yes, (72. Anonymous, Educator, Columbia Memorial Space Center, USA).

- Yes, (73. H.S., Director, Durango Discovery Museum, USA).

- Yes, 'People are multifaceted, complicated organisms. Fortunately, they are our species' (74. E.M., Educator, Explora, USA).

- Yes, 'Occasionally, an exhibit will need to address more than one cultural issue' (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).


- Yes, (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).

- Yes, (80. Anonymous, Education Manager/Staff Scientist,
Connecticut Science Center, USA).

- Yes, (81. Anonymous, Director, Explora, USA).

- Yes, 'My definition of culture is that it is art, music, architecture, textile, food, music, and more. It defines us individually and as a community. Our cultural identity impacts on how we experience the world and that includes museum exhibits' (82. J.J.R., Director, Science Museum of Minnesota, USA).


- Yes, (84. Anonymous, Educator, Sony Wonder Technology Lab, USA).


- Yes, 'always, in exhibit design, the institution must take into account its audience or potential audience’ (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, 'Many things combine when there are issues. It is never just one thing' (87. D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

- Yes, 'Any exhibit could have multiple cultural issues' (88. S.R., Researcher, Lawrence Hall of Science, USA).


- Yes, 'I do not understand this question' (90. L.L., Director, Ocean Star Offshore Drilling Rig Museum: Offshore Energy Center, USA).


- Yes, 'Absolutely. An exhibit can be a conceptually confusing and visually difficult exhibit that's made almost exclusively for young physical boys. There are tons of ways you can get exhibits wrong' (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).


- Yes, (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).

- Yes, 'Language - written or spoken' (96. N.T., Director, Houston Museum of Natural Science: HMNS, USA).
- Yes, (97. Anonymous, Project Director of Exhibits and Programs, Sciencenter, USA).

- No, 'the question is poorly worded -- do I believe that 10 dimensions can affect things more than one single dimension...yes. Do I think that they make a big difference either individually or collectively - No. If you aren't planning for handicapped access, universal signage, and most importantly have people on the floor who can demo and explain things you ought not to be in the business. If you have all of those things in place the cultural issues noted above will be at best trivial' (98. C.M., CEO: Chief Executive Officer, Miami Science Museum, USA).

- No, 'Don't understand the question -- sorry' (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).

- Yes, (103. D.R., Director, Fleischmann Planetarium and Science Center, USA).

- Yes, 'All of these are important factors in creating successful exhibits' (104. M.B., Researcher, The Franklin Institute, USA).

- Yes, 'The more inhibitors or factors that are present in an exhibit the less likely people are to interact with it. You can see this in many exhibits that sit idle while others that are more accessible on multiple levels get used frequently. This is true with all of our popular exhibits. These are the ones that don't have any restrictions on the cultural dimensions that were listed above' (108. J.H., Director of Education, GWiz - The Science Museum, USA).

(6) Oceania

- Yes, 'Language issues combined with either gender or social issues can work to affect the way visitors interact with an exhibit' (5. S.S., curator, Exscite centre - Waikato Museum, New Zealand).


- No, (30. A.H., Director, Scitech, Australia).

- Yes, 'Accessibility tends to be the most influential aspect within exhibit development' (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

- Yes, 'Each of these 10 dimensions interact and can multiply the affect that they have on an exhibit' (37. C.W., Exhibitor, Monash Science Centre, Australia).


- No, (61. A.B., Director, Scitech, Australia).
(7) Russia
- No, (119. I.K., Director, Experimentanium Science center, Russia).

(8) South America
- Yes, 'Any dimension of cultural issues affects the exhibits by more than one dimension' (68. A.C.P., Director, Espaço Ciência, Brazil).
- Yes, (70. F.A., Director, Centro interactivo de Ciencias - La Punta, Argentina).
- Yes, 'All the dimensions can affect the exhibits. It is important to make a careful design and preliminary studies in order to properly address these issues' (75. M.K., Evansville, Former Director, Brazil).
- Yes, 'I can understand your point of view though this is not the case in our centre' (79. V.P., Educator, Espacio Ciencia LATU, Uruguay).
- Yes, 'The dimensions are not excludent' (101. M.H., Designer, Ciencia Viva, Uruguay).
- Yes, 'Language issues, conceptual understanding and visual cultures' (102. M.E.V., Educator, Museu de Astronomia e Ciências Afins: MAST, Brazil).
- Yes, 'All of them' (107. E.H., Director, Maloka, Colombia).
- Yes, (114. P.D.S., Director, Museo del Mar, Argentina).
- Yes, 'For example, for a foreigner two or more at these issues will always be present, making the use at the exhibits harder, in any place at the world' (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).
- Yes, (116. V.V., Educator, Museo Interactivo Mirador: MIM, Chile).

20. Are there any more cultural issues that you believe should be considered?

<table>
<thead>
<tr>
<th>Cultural regions</th>
<th>The experts comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Africa</td>
<td>'May religious issues' (109. A.Z., Director, Tunis Science City, Tunisia).</td>
</tr>
<tr>
<td>(2) Asia</td>
<td>'Believing/non believing in God/religion is one issue which may influence visitors approach' (9. S.J.S., curator, Science City Kolkata, India).</td>
</tr>
<tr>
<td></td>
<td>'Educational qualifications of visitors of region' (19. U.K., curator, Nehru Science Centre, India).</td>
</tr>
<tr>
<td></td>
<td>'no', (23. K.C.C., volunteer, National Museum of Natural Science in</td>
</tr>
</tbody>
</table>
Taiwan, China).


- ‘No’, (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).

- ‘Visitor movement pattern, either right-handed or left-handed is also culture-specific. Choice of colours is another example where cultural preferences need to be considered’ (49. E.I., Director, Birla Industrial & Technological Museum: BITM, India).

- ‘I think you need to define more inaccurate cultural issues’ (56. D.A.P., Curator, Bloomfield Science Museum Jerusalem, Israel).

- ‘Difference between speaking and writing language, e.g. Cantonese and Mandarin - confusion of the meaning of words’ (58. O., Curator, Communications Museum of Macao, China).

- ‘Typical say an exhibit using vacuum or moving parts where the visitor is wearing robes that can get entangled’ (60. M.B., Science Show and Exhibit Design Consultant, National Science Museum, Thailand).

(3) Europe

- ‘We get very occasional questions on why our exhibits are not captioned in Irish or Ulster Scots. We have been asked why our coverage of mythology in astronomy does not include Irish mythology’ (1. C.J., Science Communicator, UK).

- ‘I think you may be trying to reduce an incredibly complex field into too simple a system. Many issues (visual design, social norms etc) are different in different cultures. For most the cultural dimension is only important insofar as the exhibits are developed in line with the culture they sit within. The biggest variation I see between science centres around the world is the attitude towards learning and education (i.e. didactic, factual learning vs. experiential, emotional outcomes) which reflect local mores’ (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).

- ‘I think cultural interests themselves influence how we interact with exhibits - does the exhibit refer to or cover a concept that relates to the visitor’s own interests e.g. common hobbies, popular entertainment etc.’ (3. S.W, educator, Benjamin Franklin House, UK).


- ‘For example you used to open a screw in Russia to different direction than in Finland. The Russian pattern was easy for a left handed person’ (33. P.J., Exhibition Manager, Heureka, the Finnish
Science Centre, Finland).

- ‘Written Language. Trying to decide which language things should be labelled in is not easy. In general we write everything in both Italian and English with mini-guides available in PDF files for free download from our website in many other languages but the visitor must plan ahead of time to access and print these out’ (39. D.K.M.G., Educator, Museo Galileo, Italy).

- ‘Nodding has different meaning in Europe and Asia. Also some exhibits for small children do not work the same way in different cultures. And as I have talked to exhibit producer from US he said that children in Kuwait do not touch exhibits. In US they expect to touch everything’ (44. P.K., Director, AHHAA Science Centre, Estonia).

- ‘Difference in school levels and teachers attitudes. S & T is suited for everyone but some groups need more help or different settings’ (46. L.H., Educator, Science Centre Delft: TUDelft, Netherlands).

- ‘Religious concerns should also be considered’ (48. B.A., Exhibitor, Neanderthal Museum, Germany).

- ‘As mentioned above (cf. question 11.) I think, that the different forms of cultural knowledge deriving from different educational, professional and social backgrounds of the visitors also influence the access to interactive exhibits and therefore should be observed’ (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).

- ‘Religion’ (53. S.P., Director, Observatory Science Centre, UK).


- ‘Learning styles. For example, in Asia, we have a very didactic teaching style. Questions are asked and correct answers are expected. In the western world, there is a greater emphasis on exploring and coming to conclusions oneself. I believe this is a big difference’ (111. C.L., Exhibitions Manager, Thinktank Birmingham Science Museum, UK).

- ‘I think you should try and separate cultural issues like women wearing skirts on bicycles from national standards like the direction of switch operation. Probably best to adopt the standards and culture of the home country’ (117. G.B., Curator, Tyne and Wear Archives & Museums, UK).

- ‘Non-physical disabilities, e.g. autism’ (121. M.S., Team Leader, Science Museum London, UK).
(4) Middle East
- 'Some religious groups need a private place to go pray during their visit' (12. Anonymous, curator, Kalamazoo Aviation History Museum, USA).
- 'Educational level? Do people think they belong in a science center or that they can think for themselves?' (13. L.M., researcher, Arizona Science Center, USA).
- 'Better surveys' (35. K.P. Director of Exhibit Services, Exploratorium, USA).
- no, (51. M. Bilingual Evaluation Assistant, Oregon Museum of Science and Industry: OMSI, USA).
- 'I'm not familiar with any' (63. D.J., Educator, Clark Planetarium, USA).
- 'I think the best exhibits are intuitive--and don't need labels/graphics. But there may be a culture issue regarding the ability to read--for example, young children cannot read. Exhibits should be designed so that a visitor can figure it out without reading' (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).
- 'Some of our exhibits are not made for shorter stature people' (67. G.B. Curator, SciTech Hands On Museum, USA).
- 'It depends on how you are defining "culture" ' (69. S., Exhibit Developer, Creative Discovery Museum, USA).
- 'Similar to age--generational values affect exhibit value' (73. H.S., Director, Durango Discovery Museum, USA).
- 'Maybe some consideration regarding what science is exactly. Is it a set of facts that one person imparts on another, or is it a process by which we learn about our world?' (74. E.M., Educator, Explora, USA).
- 'Errors of omission are hard to find when you are not intimately involved with a problem. I think you have covered most of them' (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).
- 'I wonder if the colors of exhibits or symbols used can affect the mood of people wanting to use the exhibit if they connect to cultural icons (like flags) or those of cultures that the people do not like because of historical rivalries’ (77. Anonymous, Educator, The
Discovery Museums, USA).

- 'I do not think the following should be considered as much but are cultural issues that should be made aware of. Race Size of the guests. The value of education affects how a person interacts with an exhibit' (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).

- 'I think there are cultural issues involved in doing surveys, and they need to be considered' (81. Anonymous, Director, Explora, USA).

- 'Multiple intelligences might be considered' (82. J.J.R., Director, Science Museum of Minnesota, USA).

- 'We like to design our exhibits so that they can become social explorations' (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).

- 'Religious beliefs. Many religions have difficulty with science explanations, such as evolution, the extent of the universe, what gods control versus what the physical reality controls, etc.' (87. D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

- 'I wonder about political and religious issues, as well. Science museums often have to worry about religious people's beliefs when they make evolution exhibits' (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).

- 'None' (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).

- 'I think a further careful review of multi-language communication would be advantageous to your study. Technology isolates the written interpretation (i.e., select a screen that delivers the interpretation in the language of your choice) while observation of our visitors has shown that intergenerational audiences often move back and forth between two languages on a written graphic panel when both are visible at the same time - so selecting your own language from a menu is helpful but it isolates the experience, especially in a bilingual environment like Miami Florida' (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).

- 'Age, educational background, previous science experiences, personal interests' (104. M.B., Researcher, The Franklin Institute, USA).

- 'Not that I can think of at this time' (108. J.H., Director of Education, GWIZ - The Science Museum, USA).

(6) Oceania


- 'Regional issues, such as state of origin can affect a visitor's
perspective on what's presented within an exhibit in terms of water usage, politics, agricultural income, mining profits, etc.’ (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

- ‘Religious issues. Including more than one religious tradition in an example, or sometimes making a conscious decision not to include the religious element and only present widely accepted facts. Also putting up signage that the exhibit may cause religious offence before people enter an area’ (37. C.W., Exhibitor, Monash Science Centre, Australia).

- ‘Religious issues are a big factor. We are unable to show Leonardo da Vinci's Vitruvian Man or other works in some Muslim countries’ (55. Anonymous, Museum Supplier, Grande Exhibitions, Australia).

(7) Russia

- ‘The most important - the visitor should feel concern of museum about themselves: oldies, disabled, people with babies, people with cardio stimulators, etc. Then all emotional issues are 99% solved’ (119. I.K., Director, Experimentarium Science center, Russia).

(8) South America

- ‘The cultural issue involving the explainers. This is significant, for example, in South America museums where the monitor has a more proactive role compared to European and American museums’ (68. A.C.P., Director, Espaco Ciência, Brazil).

- ‘The facilities, like bathrooms’ (70. F.A., Director, Centro interactivo de Ciencias - La Punta, Argentina).


- ‘The important issue of "language" and interest of the children and young people was not raised. I believe that it is fundamental to use the proper language, videogames, computers, iPods, etc... ’ (75. V.P., Educator, Espacio Ciencia LATU, Brazil).

- ‘Economic and social differences. Countryside people, who do not have usually access to cultural activities' (79. Virginia Puntigliano, Educator, Espacio Ciencia LATU, Uruguay).

- ‘Education, economic status, ethnic groups. partners they are with, INTERESTS ¡¡!! People come with different expectations’ (107. E.H., Director, Maloka, Colombia).

- ‘We can't think at any in this moment’ (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).
21. Which one is the most important cultural issue in your museum?

<table>
<thead>
<tr>
<th>Cultural regions</th>
<th>The experts comment</th>
</tr>
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<tbody>
<tr>
<td><strong>(1) Africa</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- ‘Language issues’ (100. J.J.A., Director, Ghana Planetarium Science Centre, Ghana).</td>
</tr>
<tr>
<td></td>
<td>- ‘Conceptual understanding’ (105. M., Science Centre Manager, Sci-Bono Discovery Centre, South Africa).</td>
</tr>
<tr>
<td></td>
<td>- ‘Language issues’ (109. A.Z., Director, Tunis Science City, Tunisia).</td>
</tr>
<tr>
<td></td>
<td>- ‘Conceptual understanding’ (120. A.L., Educator, Cape Town Science Centre, South Africa).</td>
</tr>
<tr>
<td><strong>(2) Asia</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- ‘Language issues’, (38. C.L.L., Evaluator, Science Centre Singapore, Singapore)</td>
</tr>
<tr>
<td></td>
<td>- ‘Language issues’, (49. E.I., Director, Birla Industrial &amp; Technological Museum: BITM, India).</td>
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<td>- ‘Cannot address this question. We have to address several issues in the design of each exhibit’ (56. D.A.P., Curator, Bloomfield Science Museum Jerusalem, Israel).</td>
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<tr>
<td></td>
<td>- ‘Conceptual understanding’, (60. M.B., Science Show and Exhibit</td>
</tr>
</tbody>
</table>
Design Consultant, National Science Museum, Thailand).

(3) Europe

- ‘Attitude towards the purpose of “Learning”’, (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).
- ‘Conceptual understanding’, (24. A.C., project manager, Centre for Science Education (CSE), Greece).
- ‘Open ended playfulness to be achieved across all cultures’, (25. Anonymous, Exhibit Manager, Eureka! The National Children's Museum, UK).
- ‘Conceptual understanding’, (27. G., Sub-Director, mmaca Museu de Matemàtiques de Catalunya, Spain).
- ‘Conceptual understanding’, (29, J.Š., Educator, iQpark, Czech Republic).
- ‘I don’t understand this question’, (33. P.J., Exhibition Manager, Heureka, the Finnish Science Centre, Finland).
- ‘Language issues’, (34. S.A., Educator, National Space Centre, UK)
- ‘Technologies issues’, (41. J.A.A., Head of the Science Center, Oslo Science Center, Norway).
- ‘Language issues’, (42. N.D., Coordinator of Science Exhibitions, Belgrade's Science festival and Science Park Belgrade, Serbia).
- ‘Social issues’, (43. M.B., Director of Media and Learning Center, Experimentarium, Denmark).
- ‘Language issues’, (44. P.K., Director, AHHAA Science Centre, Estonia).
- ‘I can’t give a general answer to that question, because several aspects are important’ (52. A.S., Curator, TECHNOSEUM Landesmuseum für Technik und Arbeit in Mannheim, Germany).
- ‘Emotional values’, (53. S.P., Director, Observatory Science Centre, UK).
- ‘All and more’, (111. C.L., Exhibitions Manager, Thinktank Birmingham Science Museum, UK).
- ‘Conceptual understanding’, (112. I.F., Centro Ciência Viva de Bragança, Coordinator of explainers, Portugal).
- ‘All are important’, (118. Anonymous, Educator, Enginuity - The Ironbridge Gorge Museum, UK).

(4) Middle East

(5) North America
- ‘Several of the above, depending on the site (we have many sites)’
(7. Anonymous, interpretation specialist, National Parks and National Historic Sites, Canada).


- ‘Language issues’ (13. L.M., researcher, Arizona Science Center, USA).


- ‘Conceptual understanding’ (35. K.P. Director of Exhibit Services, Exploratorium, USA).


- ‘Conceptual understanding’ (57. R.S., Executive Associate Director, Exploratorium, USA).


- ‘Conceptual understanding’ (63. D.J., Educator, Clark Planetarium, USA).

- ‘Language issues’ (64. H.H., Director, Connecticut Science Center, USA).

- ‘Disabled people’ (65. J.S., Exhibitor, Columbus Ohio's dynamic Center of Science and Industry: COSI, USA).
- 'Language issues' (69. S., Exhibit Developer, Creative Discovery Museum, USA).
- 'Language issues' (72. Anonymous, Educator, Columbia Memorial Space Center, USA).
- 'Prior age' (73. H.S., Director, Durango Discovery Museum, USA).
- 'Physical skills' (74. E.M., Educator, Explora, USA).
- 'Disabled people' (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).
- 'Prior age' (77. Anonymous, Educator, The Discovery Museums, USA).
- 'Language issues' (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).
- 'Technologies issues' (80. Anonymous, Education Manager/Staff Scientist, Connecticut Science Center, USA).
- 'Language issues' (81. Anonymous, Director, Explora, USA).
- 'I don't think one is most important, we consider all of these' (82. J.J.R., Director, Science Museum of Minnesota, USA).
- 'Social issues' (84. Anonymous, Educator, Sony Wonder Technology Lab, USA).
- 'Our museum serves a relatively small, homogeneous local population' (85. Anonymous, Educator, Lakeview Museum of Arts & Sciences, USA).
- 'Language issues' (88. S.R., Researcher, Lawrence Hall of Science, USA).
- "Language issues" (90. L.L., Director, Ocean Star Offshore Drilling Rig Museum: Offshore Energy Center, USA).


- "Gender issues" (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).

- "Language issues" (93. S.S., Curator, National Museum of Dentistry, USA).

- "Conceptual understanding" (94. P.V., Director, Museum of Nature & Science, USA).

- "Conceptual understanding" (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).

- "all" (96. N.T., Director, Houston Museum of Natural Science: HMNS, USA).

- "Language issues" (97. Anonymous, Project Director of Exhibits and Programs, Sciencenter, USA).

- "Physical skills" (98. C.M., CEO: Chief Executive Officer, Miami Science Museum, USA).

- "Language issues" (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).

- "Technologies issues" (103. D.R., Director, Fleischmann Planetarium and Science Center, USA).

- "I can't choose just one" (104. M.B., Researcher, The Franklin Institute, USA).


(6) Oceania


- "Social issues", (30. A.H., Director, Scitech, Australia).

- "Technologies issues", (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

- "Language issues", (37. C.W., Exhibitor, Monash Science Centre, Australia).

- ‘Social issues’, (61. A.B., Director, Scitech, Australia).

(7) Russia
- ‘I don’t see any’ (119. I.K., Director, Experimentarium Science center, Russia).

(8) South America
- ‘Conceptual understanding’ (68. A.C.P., Director, Espaço Ciência, Brazil).
- ‘Technologies issues’ (70. F.A., Director, Centro interactivo de Ciencias - La Punta, Argentina).
- ‘Language issues’ (75. M.K., Evansville, Former Director, Brazil).
- ‘Social issues’ (79. V.P., Educator, Espacio Ciencia LATU, Uruguay).
- ‘Emotional values’ (102. M.E.V., Educator, Museu de Astronomia e Ciências Afins: MAST, Brazil).
- ‘Social issues’ (107. E.H., Director, Maloka, Colombia).
- ‘Visual cultures’ (114. P.D.S., Director, Museo del Mar, Argentina).
- ‘Conceptual understanding’ (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).
- ‘Conceptual understanding’ (116. V.V., Educator, Museo Interactivo Mirador: MIM, Chile).

22. Can you make any comments or further suggestions?

<table>
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<td>- ‘No’ (109. A.Z., Director, Tunis Science City, Tunisia).</td>
</tr>
<tr>
<td></td>
<td>- ‘In our science centre, a big issue is that some visitors are too lazy to read the instructions/information posted on the exhibits. When we reopened recently we made an effort to include images that can help visitors see how the concept is carried through to everyday life. However, you still find those who just use it in any way, they think it should be used. Even with facilitators on the floor available to help them, they would rather just do it their way without looking at the information given. This can sometimes lead to them making wonderful discoveries on their own or just breaking the exhibits down. Having diverse cultures in South Africa, we find this attitude is more prevalent in certain cultures but not restricted to any either’ (120. A.L., Educator, Cape Town Science Centre, South Africa).</td>
</tr>
</tbody>
</table>
(2) Asia

- ‘In this survey, I’m taking the term ‘culture’ to mean local/Singaporean understanding in general, as we are a multi-cultural country, I have not answered the survey in terms of a particular culture e.g. the Chinese culture, the Malay culture or the Indian culture’ (40. D.T., Director of Exhibitions, Science Centre Singapore, Singapore).

- ‘None in particular’, (49. E.I., Director, Birla Industrial & Technological Museum: BITM, India).

- ‘The exhibits in the Science and Technology Museum are designed to be more interesting and accessible to attract audience to participate, and learn the knowledge and applications in the real world’ (50. Anonymous, Designer, China Science and Technology Museum, China).

- ‘The change relationship of culture and value’ (58. O., Curator, Communications Museum of Macao, China).

- ‘It is obvious that exhibits should be designed in the culture where they are used and the graphics written in that language and translated to other languages if required’ (60. M.B., Science Show and Exhibit Design Consultant, National Science Museum, Thailand).

(3) Europe

- ‘See point 20. I think cultural variation, while interesting, is only one aspect of the complexity of exhibit development. When you are inviting people into a new environment, introducing conceptually difficult new ideas using unfamiliar interfaces that need to be understandable in a few seconds (usually before any instructions are absorbed), and the interfaces have to work for any visitor irrespective of age, gender or education level, then there many issues to consider and balance. Cultural variation is one of these, and I will be interested to see how your findings fit into the wider picture. Will you be participating in any of the UK or European conferences?’ (2. A.L., Special Projects Manager, Life Science Centre: Centre for Life, UK).


- ‘Cultural issues affect the use of interactive exhibits. These issues should be considered very seriously when design the exhibits but also the Science Centre as a whole. Of course this consideration apply to SCs that have a large international audience’ (24. A.C., project manager, Centre for Science Education (CSE), Greece).

- ‘I think your investigation is really interesting, especially for someone who is beginning to design exhibits, like our association does. Some of your questions are familiar in our discussions, some need to be immediately incorporated to it and that we start to incorporate solutions in our proposal. Other will be very important if we want to diffuse our work. Thanks for your useful investigation’
- 'We recently worked with the National Science Museum of Thailand, a most enjoyable experience' (53. S.P., Director, Observatory Science Centre, UK).

- 'I wish you a luck in your survey, there are some parts that could be more relevant than other, maybe you should focus yourself on those (language, signs and other visual symbols etc.)' (106. D.E., Head of Exhibitions and Publishing, Center for the Promotion of Science, Serbia).

- 'I am very interested in the topic you are pursuing. As a Singaporean working in the UK the last 8 years, I do see cultural differences that I have to take into consideration in the design and development of the exhibitions I am involved in. I am happy to have a follow up phone conversation especially as I am rather confused about a couple of questions you have posed here. You can get in touch on 0121 202 2316' (111. C.L., Exhibitions Manager, Thinktank Birmingham Science Museum, UK).

- 'It is probably impossible to try and satisfy the cultural and emotional sensitivities of everyone who might visit your science centre- best to try and get it right for the home population. The science of course is universal' (117. G.B., Curator, Tyne and Wear Archives & Museums, UK).

- 'All visitors need to be made comfortable first before anything else is possible' (121. M.S., Team Leader, Science Museum London, UK).

(4) Middle East

(5) North America

- 'Your use of the term "cultural" is problematic - many of these are not "cultural" but are design and communication affordances. Using a term like "cultural" comes weighted with implications regarding attitudes, multicultural landscapes and other factors. If we eliminate the term "cultural" from your questions it becomes easier to answer and interpret - applying cultural to them alters their context in ways that really don't make sense (for example, design affordances and construction for universal access is an important issue - but adding the term cultural opens it to wider interpretation - are you asking about cultural attitudes to the disabled and universal access, are you asking how different cultures in our audience respond to those with different abilities, are you asking about the culture of disability?" (8. D.H., director, TELUS Spark, Canada).


- ‘From my responses, you can sense my profound discomfort with many of the assumptions behind these questions. The notion that there is "one" message, "one best way" to communicate is deeply

- 'I don't believe that you are going to get much useful data on this subject with this method. You really should go to a science center and actually observe what people do and say. Most of what you have shown here may be the result of cultural misunderstanding, but much of it is sloppy design, or emphasis on the wrong priorities for developing interactive experiences' (35. K.P. Director of Exhibit Services, Exploratorium, USA).

- 'All of the above are important. I checked the one that currently has the most resources devoted to it' (47. Anonymous, Evaluator, Oregon Museum of Science and Industry: OMSI, USA).

- 'Yes, there are always going to be differences amongst visitors to exhibits or information in general. They may be cultural or otherwise, you will never have the exact same response from any two people from even similar cultural backgrounds. That is the nature of the world and I see it as an opportunity to learn, just as much as the exhibit content is an opportunity to learn about something unfamiliar' (59. A.G., Designer, Cape Fear Museum of History and Science, USA).

- 'We are in the process of designing new interactive exhibits. Formative evaluation with audiences is key. Visitors never use exhibits the way we think they will and they never understand what we'd like them to understand with the first round of text and graphics' (63. D.J., Educator, Clark Planetarium, USA).

- 'I think that people that visit museums do so with the understanding that their personal cultural issues need to be curbed to get the most out of the experience, be flexible and open to new ideas and concepts' (67. G.B. Curator, SciTech Hands On Museum, USA).

- 'Appealing to the widest range of ages is a big challenge' (73. H.S., Director, Durango Discovery Museum, USA).

- 'Good luck. Many of these concerns will disappear if exhibits are focused on what people can do and learn instead of what you think people should do and learn. People are smart especially when other people don't think for them' (74. E.M., Educator, Explora, USA).

- No comment, (76. Anonymous, Director, Museu Exploratório de Ciências - Unicamp, USA).

- 'Spell check the survey. Also, explain more about what you want from the participant. For example, the line "Please explain your answer, if one of your exhibits show this issue." is confusing. "If one of your exhibits show this issue, please explain your answer" states that you should only explain if the exhibit has the issue. The first line states "Please explain your answer" first' (78. Anonymous, Educator, Sci-Tech Discovery Center, USA).

- 'I think some of your questions are repetitive and a bit hard to
understand. I am not sure I answered them correctly' (82. J.J.R., Director, Science Museum of Minnesota, USA).

- 'You seem to over-think some of the issues - all people have a choice whether to use an exhibit or not. No museum can cover all variables' (83. Anonymous, Educator, GWIZ - The Science Museum, USA).

- 'In my last six year research study funded by NSF, we found that content can really be defined as not only what the exhibit is sharing but also content is becoming familiar with how to use the exhibit' (86. J.L., Researcher-Evaluator-Educator, Museum of Science and Industry: MOSI, Chicago, USA).

- 'I believe that cultural issues may becoming less of a concern, as the Internet and the global economy has all people of the world interacting more. People from one part of the planet can see what others do, how they do it, and appreciate the differences' (87. D.C., Exhibitor, Museum of Science and Industry: MOSI, Chicago, USA).

- 'These are all absolutely cultural issues, but they're all also just usability issues that get even more complicated by cultural differences that you didn't expect. Every time you make an exhibit, you make assumptions about things people will find understandable, do-able, compelling, attractive, etc. Ideally you prototype your exhibits with your visitors to make sure that the assumptions you made add up to an exhibit that communicates what you want. Rarely do you get it right the first time - often there are things you need to change. Cultural differences are often places where certain visitors defy your expectations. The tough thing is when you don't know what to look for, or when an exhibit is translated into another culture. For instance, the "Real Image" exhibit was created where people shake hands. It must never have occurred to them that it would confusing in a Thai museum. The exhibits we make are rooted in our own cultural assumptions, which are often invisible to us until we prototype. --And until we prototype it with new users' (92. P.M., Exhibit Projects Creative Director, New York Hall of Science, USA).

- 'No' (95. C.K.B., Associate Director, Imiloa Astronomy Center of Hawaii, USA).

- 'That's about all I have time for... thanks for asking me to respond' (99. S.D., Vice President, Exhibition and Design, Mobius Science Center, USA).

- 'All of these factors are relevant to creating successful exhibits. That is why we always build prototypes of interactive exhibit devices and try them out with visitors before building the final exhibit' (104. M.B., Researcher, The Franklin Institute, USA).

(6) Oceania

- 'My only other suggestion would be to include a more detailed description of culture and cultural issues in this survey' (5. S.S.,...
- ‘Cultural issues are fundamental to the design of exhibits as every individual has a base knowledge due to that environment and they interact via that filter’ (31. C.C., Concept developer and education, Questacon - The National Science and Technology Centre, Australia).

(7) Russia

- ‘No more suggestions’ (119. I.K., Director, Experimentanium Science center, Russia).

(8) South America

- ‘Do not hesitate to contact me if you need further questions’ (75. M.K., Evansville, Former Director, Brazil).

- ‘Please read all the books of John Falk, Thriving in the knowledge age is fantastic. Contact Institute of Innovation in LEARNING. Please define Culture, because for us it is about all the dreams, skills, attitudes etc of a social group. I would not separate any of the topics you asked about. See each person as an integral human being’ (107. E.H., Director, Maloka, Colombia).

- ‘In our museum when an exhibition is thought and design, we try to think at all these issues before it’s fabrication, so they can be as inclusive as possible’ (115. L.L., Director of Educational Department, Museo Interactivo Mirador: MIM, Chile).
## Appendix 12: Ethical clearance approval

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**Ethics Approvals (Human Participants) Sub-Committee**

### Ethical Clearance Checklist

<table>
<thead>
<tr>
<th>Has the Investigator read the ‘Guidance for completion of Ethical Clearance Checklist’ before starting this form?</th>
<th>Yes</th>
</tr>
</thead>
</table>

### Project Details

1. **Project Title:** An investigation into the importance of cultural barriers to the understanding of science and technology exhibits

### Applicant(s) Details

<table>
<thead>
<tr>
<th>2. Name of Applicant 1:</th>
<th>Sumath Awsakulsutthi</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Status:</td>
<td>UG Student/PGT student/PGR student/Staff</td>
</tr>
<tr>
<td>4. School/Department:</td>
<td>Loughborough Design School</td>
</tr>
<tr>
<td>5. Programme (if applicable):</td>
<td>PhD</td>
</tr>
<tr>
<td>6. Email address:</td>
<td><a href="mailto:S.Awsakulsutthi@lboro.ac.uk">S.Awsakulsutthi@lboro.ac.uk</a></td>
</tr>
<tr>
<td>7a. Contact address:</td>
<td>B8 The Print House, 58-60 Wood Gate, Leicestershire, LE11 2QD</td>
</tr>
<tr>
<td>7b. Telephone number:</td>
<td>07440 546101</td>
</tr>
<tr>
<td>8. Supervisor:</td>
<td>Yes/No</td>
</tr>
<tr>
<td>9. Responsible Investigator:</td>
<td>Yes/No</td>
</tr>
<tr>
<td>10. Name of Applicant 2:</td>
<td>Nigel Zanker</td>
</tr>
<tr>
<td>11. Status:</td>
<td>UG Student/PGT student/PGR Student/Staff</td>
</tr>
<tr>
<td>12. School/Department:</td>
<td>Loughborough Design School</td>
</tr>
<tr>
<td>13. Programme (if applicable):</td>
<td></td>
</tr>
<tr>
<td>14. Email address:</td>
<td><a href="mailto:N.P.Zanker@lboro.ac.uk">N.P.Zanker@lboro.ac.uk</a></td>
</tr>
<tr>
<td>15a. Contact address:</td>
<td>Loughborough Design School, Loughborough University</td>
</tr>
<tr>
<td>15b. Telephone number:</td>
<td>01509 222661</td>
</tr>
<tr>
<td>16. Supervisor:</td>
<td>Yes/No</td>
</tr>
<tr>
<td>17. Responsible Investigator:</td>
<td>Yes/No</td>
</tr>
</tbody>
</table>

### Participants

**Vulnerable groups**

<table>
<thead>
<tr>
<th>18. Will participants be knowingly recruited from one or more of the following vulnerable groups?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children under 18 years of age</td>
</tr>
<tr>
<td>Persons incapable of making an informed decision for themselves</td>
</tr>
<tr>
<td>Pregnant women</td>
</tr>
<tr>
<td>Prisoners/Detained persons</td>
</tr>
<tr>
<td>Other vulnerable group</td>
</tr>
</tbody>
</table>

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*Ethical Clearance Checklist October 2012*
**Appendix 12 (continued): Ethical clearance approval**

**Chaperoning Participants**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>19. Will participants be chaperoned by more than one investigator at all times?</td>
<td>No*</td>
</tr>
<tr>
<td>20. Will at least one investigator of the same sex as the participant(s) be present throughout the investigation?</td>
<td>No*</td>
</tr>
<tr>
<td>21. Will participants be visited at home?</td>
<td>No</td>
</tr>
</tbody>
</table>

**Researcher Safety**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>22. Will the researcher be alone with participants at any time?</td>
<td>No</td>
</tr>
<tr>
<td><strong>If Yes, please answer the following questions:</strong></td>
<td></td>
</tr>
<tr>
<td>22a. Will the researcher inform anyone else of when they will be alone with participants?</td>
<td>No*</td>
</tr>
<tr>
<td>22b. Has the researcher read the ‘guidelines for lone working’ and will abide by the recommendations within?</td>
<td>No*</td>
</tr>
</tbody>
</table>

**Methodology and Procedures**

23. Please indicate whether the proposed study:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Involves taking bodily samples (please refer to published guidelines)</td>
<td>No</td>
</tr>
<tr>
<td>Involves using samples previously collected with consent for further research</td>
<td>No</td>
</tr>
<tr>
<td>Involves procedures which are likely to cause physical, psychological, social or emotional distress to participants</td>
<td>No</td>
</tr>
<tr>
<td>Is designed to be challenging physically or psychologically in any way (Includes any study involving physical exercise)</td>
<td>No</td>
</tr>
<tr>
<td>Exposes participants to risks or distress greater than those encountered in their normal lifestyle</td>
<td>No</td>
</tr>
<tr>
<td>Involves collection of body secretions by invasive methods</td>
<td>No</td>
</tr>
<tr>
<td>Prescribes intake of compounds additional to daily diet or other dietary manipulation/supplementation</td>
<td>No</td>
</tr>
<tr>
<td>Involves pharmaceutical drugs</td>
<td>No</td>
</tr>
<tr>
<td>Involves use of radiation</td>
<td>No</td>
</tr>
<tr>
<td>Involves use of hazardous materials</td>
<td>No</td>
</tr>
<tr>
<td>Assists/alters the process of conception in any way</td>
<td>No</td>
</tr>
<tr>
<td>Involves methods of contraception</td>
<td>No</td>
</tr>
<tr>
<td>Involves genetic engineering</td>
<td>No</td>
</tr>
<tr>
<td>Involves testing new equipment</td>
<td>No</td>
</tr>
</tbody>
</table>
Appendix 12 (continued): Ethical clearance approval

Observation/Recording

24a. Does the study involve observation and/or recording of participants? Yes

If Yes:

24b. Will those being observed and/or recorded be informed that the observation and/or recording will take place? Yes

Consent and Deception

25. Will participants give informed consent freely? Yes

Informed consent

26. Will participants be fully informed of the objectives of the study and all details disclosed (preferably at the start of the study but, where this would interfere with the study, at the end)? Yes

27. Will participants be fully informed of the use of the data collected (including, where applicable, any intellectual property arising from the research)? Yes

28. For children under the age of 18 or participants who are incapable of making an informed decision for themselves:
   a. Will consent be obtained (either in writing or by some other means)? Yes
   b. Will consent be obtained from parents or other suitable person? Yes
   c. Will they be informed that they have the right to withdraw regardless of parental/guardian consent? Yes
   d. For studies conducted in schools, will approval be gained in advance from the Head-teacher and/or the Director of Education of the appropriate Local Education Authority? Yes
   e. For detained persons, members of the armed forces, employees, students and other persons judged to be under duress, will care be taken over gaining freely informed consent? N/A

Deception

29. Does the study involve deception of participants (i.e. withholding of information or the misleading of participants) which could potentially harm or exploit participants? No

If Yes:

30. Is deception an unavoidable part of the study? Yes No*

31. Will participants be de-briefed and the true object of the research revealed at the earliest stage upon completion of the study? Yes
### Appendix 12 (continued): Ethical clearance approval

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>32. Has consideration been given on the way that participants will react to the withholding of information or deliberate deception?</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Withdrawal</strong></td>
<td></td>
</tr>
<tr>
<td>33. Will participants be informed of their right to withdraw from the investigation at any time and to require their own data to be destroyed?</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Storage of Data and Confidentiality</strong></td>
<td></td>
</tr>
<tr>
<td>34. Will all information on participants be treated as confidential and not identifiable unless agreed otherwise in advance, and subject to the requirements of law?</td>
<td>Yes</td>
</tr>
<tr>
<td>35. Will storage of data comply with the Data Protection Act 1998?</td>
<td>Yes</td>
</tr>
<tr>
<td>36. Will any video/audio recording of participants be kept in a secure place and not released for any use by third parties?</td>
<td>Yes</td>
</tr>
<tr>
<td>37. Will video/audio recordings be destroyed within ten years of the completion of the investigation?</td>
<td>Yes</td>
</tr>
<tr>
<td>38. Will full details regarding the storage and disposal of any human tissue samples be communicated to the participants?</td>
<td>N/A</td>
</tr>
<tr>
<td>39. Will research involve the sharing of data or confidential information beyond the initial consent given?</td>
<td>No</td>
</tr>
<tr>
<td>40. Will the research involve administrative or secure data that requires permission from the appropriate authorities before use?</td>
<td>No</td>
</tr>
<tr>
<td><strong>Incentives</strong></td>
<td></td>
</tr>
<tr>
<td>41. Will incentives be offered to the investigator to conduct the study?</td>
<td>No</td>
</tr>
<tr>
<td>42. Will incentives be offered to potential participants as an inducement to participate in the study?</td>
<td>No</td>
</tr>
<tr>
<td><strong>Work Outside of the United Kingdom</strong></td>
<td></td>
</tr>
<tr>
<td>43. Is your research being conducted outside of the United Kingdom?</td>
<td>No</td>
</tr>
<tr>
<td>If Yes:</td>
<td></td>
</tr>
<tr>
<td>44. Has a risk assessment been carried out to ensure the safety of the researcher whilst working outside of the United Kingdom?</td>
<td>Yes</td>
</tr>
<tr>
<td>45. Have you considered the appropriateness of your research in the country you are travelling to?</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* Ethical Clearance Checklist: October 2012
Appendix 12 (continued): Ethical clearance approval

| 46. Is there an increased risk to yourself or the participants in your research study? | Yes* | No |
| 47. Have you obtained any necessary ethical permission needed in the country you are travelling to? | Yes | No* |

Information and Declarations

Checklist Application Only:
If you have completed the checklist to the best of your knowledge, and not selected any answers marked with an * or †, your investigation is deemed to conform with the ethical checkpoints. Please sign the declaration and lodge the completed checklist with your Head of Department/School or his/her nominee.

Checklist with Additional Information to the Secretary:
If you have completed the checklist and have only selected answers which require additional information to be submitted with the checklist (indicated by a †), please ensure that all the information is provided in detail below and send this signed checklist to the Secretary of the Sub-Committee.

Checklist with Generic Protocols Included:
If you have completed the checklist and you have selected one or more answers in which you wish to use a Generic Protocol (indicated by #), please include the Generic Protocol reference number in the space below, along with a brief summary of how it will be used. Please ensure you are on the list of approved investigators for the Generic Protocol before including it on the checklist. The completed checklist should be lodged with your Head of Department/School or his/her nominee.

Full Application needed:
If on completion of the checklist you have selected one or more answers which require the submission of a full proposal (indicated by a *), please download the relevant form from the Sub-Committee’s web page. A signed copy of this Checklist should accompany the full submission to the Sub-Committee.

Space for Information on Generic Proposals and/or Additional Information as requested:
Appendix 12 (continued): Ethical clearance approval

For completion by Supervisor

Please tick the appropriate boxes. The study should not begin until all boxes are ticked.

☐ The student has read the University’s Code of Practice on investigations involving human participants

☐ The topic merits further research

☐ The student has the skills to carry out the research or are being trained in the requires skills by the Supervisor

☐ The participant information sheet or leaflet is appropriate

☐ The procedures for recruitment and obtaining informed consent are appropriate

Comments from supervisor:

Please see response to 28d. Read ‘museums’ instead of ‘schools’; Read ‘Museum Director’ instead of ‘Director of Education’

d. For studies conducted in schools, will approval be gained in advance from the Head-teacher and/or the Director of Education of the appropriate Local Education Authority?

Signature of Applicant: [Signature]

Signature of Supervisor (if applicable): [Signature]

Signature of Head of School/Department or his/her nominee: [Signature]

Date: Thu 17 Jan 2013
Appendix 12 (continued): Ethical clearance approval

Ethics Approvals (Human Participants) Sub-Committee

Research Proposal for Studies Involving Human Participants

Project Details

1. Project Title: 
An investigation into the importance of cultural barriers to the understanding of science and technology exhibits

2. Aims and objectives of the study
To investigate the cultural issues relating through interactive science exhibits

3. Lay summary of the study
This research is one of three case studies as part of a PhD investigating use interaction with exhibits found in museum. Data from the other two case studies have identified cultural barriers with user’s understanding of exhibits. This case study aims to test hypotheses relating to user behaviour and interaction. Visitors to two selected ‘museums’ will be invited to complete a questionnaire before and after using selected exhibits. Agreement will be asked their permission to be observed whilst using the exhibit. The ‘museums’ involved are the National Space Centre (Leicester) and Snibston Discovery Museum (Coalville). Permission has been given by key personnel in these centres to pursue this enquiry. They have welcomed the approach as being useful and contributory to their own museum development.

Note: This should be understandable to non-expert and should not be a copy of the research proposal. It should include the reasons for the research, the background to it and why the area is important to investigate.

4. Start date of study: Jan 2013

5. End date of study: Oct 2013

6. Duration of the study: Jan 2013 – Oct 2013

7. Start date for data-collection: Feb 2013

Note: Data collection should not commence before final ethical approval is confirmed.

8. Location of the study: The National Space Centre, Leicestershire and Snibston Discovery Museum

9. Reasons for undertaking the study (e.g. contract, student research): PhD Research

10. Do any of the researchers stand to gain from a particular conclusion of the research study? No

550
Appendix 12 (continued): Ethical clearance approval

If Yes, how do the researchers stand to gain?

Applicant Details

11. Name of Researcher (applicant): **Sumath Awsakulsutthi**

12. Status: Undergraduate student/Postgraduate Taught student/Postgraduate Research student (delete as appropriate)

13. Email address: S.Awsakulsutthi@lboro.ac.uk

14. Contact address: 
**B8 The Print House, 58-60 Wood-Gate, Loughborough, Leicestershire, LE11 2QD**

15. Telephone number: 07440 546101

All other researchers (including supervisors if applicant is a student)

16. Name(s): Nigel Zanker

17. Status(es): Supervisor

18. Email address(es): N.P.Zanker@lboro.ac.uk

19a. Contact Address(es): Loughborough Design School, Loughborough University, LE11 3TU, UK

19b. Telephone number(s): 01509 222861

20. Experience of all investigators in the methods to be used in this study

   **Note:** Please ensure the experience of all investigators is included in this section.

   Sumath Awsakulsutthi: Works as Science Educator at the National Science Museum in Thailand. Nigel Zanker: PhD Supervisor, Senior Lecturer and Programme Director (PGCE/MSc)

Participant Information

21. Number of participants to be recruited: **About 100-300 participants**

22. Details of participants (age, gender, special interests etc):

   *The visitors cover under 18 students and up to 60 years old. Mixed gender.*

23. How will participants be selected?

   **Note:** Include the inclusion/exclusion criteria to be used.

   *Contact the museum staff to organise its participants.*

24. How will participants be recruited and approached?

   **Note:** If an advertisement or forum post is to be used, please include this in your application to the Sub-Committee.

   *The museum staff explains the brief details to complete the paper questionnaire.*
Appendix 12 (continued): Ethical clearance approval

25. Please state the demand on participants’ time:

Note: Where possible, include a breakdown of how long each part of the study will take, as well as a total time demand.

About 10 minutes per person to fill in the paper questionnaire.

26. Will control participants be used? 

<table>
<thead>
<tr>
<th></th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>If No, please go to Question 31.</td>
<td></td>
</tr>
<tr>
<td>If Yes, please answer the questions below.</td>
<td></td>
</tr>
</tbody>
</table>

27. How will control participants be selected?

Note: Include the inclusion/exclusion criteria to be used.

28. How will control participants be recruited and approached?

Note: If an advertisement or forum post is to be used, please include this in your application to the Sub-Committee.

29. Please state the demand on control participants’ time:

Note: Where possible, include a breakdown of how long each part of the study will take, as well as a total time demand.

30. Please provide procedures for the chaperoning and supervision of the participants during the study.

31. Possible risks, discomforts and/or distress to participants. None

32. Please provide details of any payments to be made to the participants. None

Researcher Safety

33. Are there any potential risks to the researchers in this study? 

<table>
<thead>
<tr>
<th></th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>If Yes, please answer the following questions:</td>
<td></td>
</tr>
</tbody>
</table>

34. What are the potential risks to the researchers? None

35. What measures have been put in place to address these risks?

Study details

36. Brief outline of study design and methodology:

Note: It should be clear what each participant will have to do, how many times, and in what order.

All of this information is included on the Participant Information Sheet.

37. Measurements to be taken:

Note: All measurements and samples to be taken from participants should be included here.

Completion of questionnaire and photographic data.
### Appendix 12 (continued): Ethical clearance approval

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>38. Please indicate whether the proposed study:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38a. Involves taking bodily samples</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38b. Involves procedures which are physically invasive (including the collection of body secretions by physically invasive methods)</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38c. Is designed to be challenging:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physically</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Psychologically</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38d. Involves procedures that are likely to cause:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical distress to participants</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Psychological distress to participants</td>
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<td></td>
</tr>
<tr>
<td>Social distress to participants</td>
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<td></td>
</tr>
<tr>
<td>Emotional distress to participants</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38e. Involves intake of compounds additional to daily diet, or other dietary manipulation/supplementation</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38f. Involves pharmaceutical drugs (Please refer to published guidelines)</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38g. Involves testing new equipment</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38h. Involves procedures which may cause embarrassment to participants</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38i. Involves collection of personal and/or potentially sensitive data</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38j. Involves use of radiation (Please refer to published guidelines and contact the University's Radiological Protection Officer before beginning any study which exposes participants to ionising radiation)</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38k. Involves use of hazardous materials (Please refer to published guidelines)</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38l. Assists/alters the process of conception in any way</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38m. Involves methods of contraception</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>38n. Involves genetic engineering</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

If Yes, please give specific details of each of the procedures to be used and arrangements to deal with adverse effects:

**Consent**

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>39. Is written consent to be obtained from participants?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>If yes, please attach a copy of the consent form to be used. If no, please justify.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>40. Will any of the participants be from one of the following vulnerable groups?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40a. Children under 18 years of age</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>40b. Persons incapable of making an informed decision for themselves</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>40c. Prisoners/other detained persons</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>40d. Other vulnerable groups</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

**Please specify:**
Appendix 12 (continued): Ethical clearance approval

If Yes, to any of the above, please answer the following questions:

41. What special arrangements have been made to deal with the issues of consent?  
*Please see Consent forms attached*

42. Have the researchers obtained necessary police registration/clearance?  
*No*

**Note:** Please provide details or indicate why this is not applicable to your study. *Researcher will be under direct supervision of museum staff at all times.*

**Withdrawal**

43. How will participants be informed of their right to withdraw from the study?  
*Just say 'No' when they want to withdraw from the study.*

44. How will participants be informed of the issues with withdrawing their data once this has been aggregated in the study?  
*Tell them that they can withdraw from the study. Indicated on participation information sheet.*

**Storage and Security of Data**

45. Will the investigation include the use of any of the following:  

<table>
<thead>
<tr>
<th>Observation of participants</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio recording</td>
<td>Yes</td>
</tr>
<tr>
<td>Video recording</td>
<td>Yes</td>
</tr>
</tbody>
</table>

If Yes, to any, please provide details of how the recording will be stored, where specifically the recording will be stored, when the recordings will be destroyed and how confidentiality will be ensured?

46. What steps will be taken to safeguard anonymity of participants/confidentiality of personal data? *Names will not be asked for. Individual personal data (age group, gender) will not be shared with others or used for any other purpose.*

47. Please give details of where the data collected will be stored, and how the collection and storage of the data complies with the Data Protection Act 1998? *Key points from analysis of video recording, and verbal recordings quoted in PhD thesis. Recordings be stored securely in Loughborough Design School. Video and audio will be destroyed (deleted) on submission and success of the PhD thesis.*

48. If human tissue samples are to be taken, please give details of, and the timeframe for, the disposal of the tissue.  
**Note:** Please also ensure that this information is included on the Participant Information Sheet.

**Sponsorship and Insurance Cover**

49a. Is the study being sponsored?  
*No*

If Yes, please state source of funds including a contact name and address for the sponsor:  
If No, please go to question c.

49b. Is the study to be covered by the sponsors insurance?  
*Yes  No*
Appendix 12 (continued): Ethical clearance approval

If No, please confirm who will be insuring the study:

49c. Is the study to be covered by the University’s insurance? Yes

If No, please confirm who will be insuring the study:

Insurance Cover

Note: It is the responsibility of investigators to ensure that there is appropriate insurance cover for the procedure/technique.

The University maintains in force a Public Liability Policy, which indemnifies it against its legal liability for accidental injury to persons (other than its employees) and for accidental damage to the property of others. Any unavoidable injury or damage therefore falls outside the scope of the policy.

50. Will any part of the study result in unavoidable injury or damage to participants or property? No

If Yes, please detail the alternative or additional insurance cover arrangements and include the supporting documentation in this application.

The University Insurance relates to claims arising out of all normal activities of the University, but Insurers require to be notified of anything of an unusual nature.

51. Is the study classed as normal activity? Yes

If No, please check with the University Insurance Officer that the policy will cover the activity. If the activity falls outside the scope of the policy, please detail the alternative or additional insurance cover arrangements and include the supporting documentation in this application.

Declaration

I have read the University’s Code of Practice on Investigations on Human Participants and have completed this application. I confirm that the above named investigation complies with published codes of conduct, ethical principles and guidelines of professional bodies associated with my research discipline.

I agree to provide the Ethics Approvals (Human Participants) Sub-Committee with appropriate feedback upon completion of my study.

Signature of applicant: 

Signature of Supervisor (If applicable): 

Signature of Head of School/Department: 

Date: Thu 17 Jan 2013

Note: Please check to ensure you have attached all necessary documents to your application.
Appendix 12 (continued): Ethical clearance approval

### Appendix 1: Application Checklist

Please ensure that you have attached copies of the following documentation to your application:

<table>
<thead>
<tr>
<th>✓</th>
<th>For all applications:</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>Participant Information Sheet</td>
</tr>
<tr>
<td>✓</td>
<td>Informed Consent Form</td>
</tr>
<tr>
<td>Where applicable:</td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>Willingness to Participate forms (for studies involving vulnerable participants)</td>
</tr>
<tr>
<td>✓</td>
<td>Parental/Guardian Information Sheet</td>
</tr>
<tr>
<td>✓</td>
<td>Children’s Information Sheet</td>
</tr>
<tr>
<td></td>
<td>Letter of Approval(s) from Head Teacher(s)</td>
</tr>
<tr>
<td></td>
<td>Opt-Out Letters</td>
</tr>
<tr>
<td></td>
<td>Health Screen Questionnaire</td>
</tr>
<tr>
<td>✓</td>
<td>Questionnaires</td>
</tr>
<tr>
<td></td>
<td>Example Interview Questions</td>
</tr>
<tr>
<td></td>
<td>Advertisement/Recruitment material</td>
</tr>
<tr>
<td></td>
<td>Evidence of approval from other Committees (Including International organisations)</td>
</tr>
<tr>
<td></td>
<td>Additional Insurance Cover</td>
</tr>
<tr>
<td></td>
<td>Risk Assessment</td>
</tr>
</tbody>
</table>
An investigation into the importance of cultural barriers to the understanding of science and technology exhibits

Participant Information Sheet

Sumath Awsakulsutthi (investigator), LE11 3TU, Email: S.Awsakulsutthi@lboro.ac.uk

Nigel Zanker (supervisor), LE11 3TU, 01509 222661, Email: N.P.Zanker@lboro.ac.uk

What is the purpose of the study?
To investigate use of interactive science exhibits problems relating to cultural issues.

Who is doing this research and why?
Sumath Awsakulsutthi will be doing this research, supervised by Nigel Zanker. This study is part of a PhD research project supported by the Thai Government and Loughborough University.

Are there any exclusion criteria?
No

Once I take part, can I change my mind?
After you have read this information and asked any questions you will be asked to complete an Informed Consent Form. If at any time, before, during or after the sessions you wish to withdraw from the study please just contact the main investigator. You can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing.

Will I be required to attend any sessions and where will these be?
No

How long will it take?
Completion of the questionnaire will take 10 minutes. You will be observed for during the time you spend using the museum exhibits.

Is there anything I need to do before the sessions?
No.

Is there anything I need to bring with me?
No.

What type of clothing should I wear?
Normal clothes
Appendix 12 (continued): Ethical clearance approval

Who should I send the questionnaire back to?

The questionnaire will be collected from you during your visit, or it may be returned later to:
Sumath Awsakulsuthi (investigator), Loughborough Design School, LE11 3TU
email: S.Awsakulsuthi@lboro.ac.uk

What will I be asked to do?

1. Complete the first part of the questionnaire before you use the exhibits.
2. Use the exhibits indicated on the questionnaire.
3. Complete the second part of the questionnaire after you use the exhibits.

What personal information will be required from me?

Age group, ethnicity, gender and occupation. You will not be asked your name.

Are there any risks in participating?

No

Will my taking part in this study be kept confidential?

Yes, individual personal data (age group, ethnicity, gender and occupation) will not be shared with others or used for any other purpose. Key points from analysis of video recording, and verbal recordings quoted in PhD thesis. Recordings be stored securely in Loughborough Design School. Video and audio will be destroyed (deleted) on submission and success of the PhD thesis.

What will happen to the results of the study?

They will be reported in the PhD thesis of Sumath Awsakulsuthi

What do I get for participating?

There is no payment. Thank you for volunteering.

If I have some more questions who should I contact?

Sumath Awsakulsuthi (investigator), S.Awsakulsuthi@lboro.ac.uk
Nigel Zanker (supervisor), LE11 3TU, 01509 222661 N.P.Zanker@lboro.ac.uk

What if I am not happy with how the research was conducted?

If you are not happy with how the research was conducted, please contact Mrs Zoe Stockdale, the Secretary for the University’s Ethics Approvals (Human Participants) Sub-Committee:

Mrs Z Stockdale, Research Office, Rutland Building, Loughborough University, Epinal Way, Loughborough, LE11 3TU. Tel: 01509 222423. Email: Z.C.Stockdale@lboro.ac.uk

The University also has a policy relating to Research Misconduct and Whistle Blowing which is available online at http://www.lboro.ac.uk/admin/committees/ethical/Whistleblowing(2).htm. Please ensure that this link is included on the Participant Information Sheet.
An investigation into the importance of cultural barriers to the understanding of science and technology exhibits

INFORMED CONSENT FORM

(To be completed after Participant Information Sheet has been read)

The purpose and details of this study have been explained to me. I understand that this study is designed to further scientific knowledge and that all procedures have been approved by the Loughborough University Ethical Advisory Committee.

I have read and understood the information sheet and this consent form.

I have had an opportunity to ask questions about my son's/daughter's participation.

I understand that my son/daughter is under no obligation to take part in the study.

I understand that my son/daughter has the right to withdraw from this study at any stage for any reason, and that they will not be required to explain their reasons for withdrawing.

I understand that all the information I provide will be treated in strict confidence and will be kept anonymous and confidential to the researchers unless (under the statutory obligations of the agencies which the researchers are working with), it is judged that confidentiality will have to be breached for the safety of the participant or others.

I agree to for my son/daughter to participate in this study.

Child's name

Your name

Your signature

Signature of investigator

Date
Appendix 12 (continued): Ethical clearance approval

An investigation into the importance of cultural barriers to the understanding of science and technology exhibits

INFORMED CONSENT FORM
(to be completed after Participant Information Sheet has been read)

The purpose and details of this study have been explained to me. I understand that this study is designed to further scientific knowledge and that all procedures have been approved by the Loughborough University Ethical Approvals (Human Participants) Sub-Committee.

I have read and understood the information sheet and this consent form.

I have had an opportunity to ask questions about my participation.

I understand that I am under no obligation to take part in the study.

I understand that I have the right to withdraw from this study at any stage for any reason, and that I will not be required to explain my reasons for withdrawing.

I understand that all the information I provide will be treated in strict confidence and will be kept anonymous and confidential to the researchers unless (under the statutory obligations of the agencies which the researchers are working with), it is judged that confidentiality will have to be breached for the safety of the participant or others.

I agree to participate in this study.

Your name __________________________

Your signature __________________________

Signature of investigator __________________________

Date __________________________
Appendix 12 (continued): Ethical clearance approval

An investigation into the importance of cultural barriers to the understanding of science and technology exhibits
Child and young person’s assent form

My name is [Child’s name]...........................................

I know what the ‘title’ study is about.
I understand what taking part involves.
I know that everything I tell you is private.
I know that if you think I or others might not be safe, you will have to tell somebody.
I am happy for you to write down/record what I say to you.
I know that you will write a report that will include the things I tell you.
I know that I do not have to answer all of the questions.
I know that I can stop talking to you at any time.
I know that no one will mind if I want to stop talking to you.

I am happy to take part in the ‘cultural barriers to the understanding of science and technology exhibits’ research

................................................................. [child’s name]

I Sumath Awsakulsutthi confirm that I have told [.................................................................] about the research project and given them the information leaflet. To the best of my knowledge they have understood what I have told them and they are giving free consent.

..............................................................................[researcher’s name]
Appendix 13: Paper-based questionnaire in Case study 3

Pre-test paper questionnaire

This question is about use of interactive science exhibits.

Date: …………………………... No ………...

Gender: ☐ Male ☐ Female

Age range: ☐ Under 20 ☐ 20-29 ☐ 30-39 ☐ 40-49
☐ 50-59 ☐ Over 60

Study level: ☐ Primary school ☐ Secondary school ☐ College ☐ Undergraduate
☐ Post graduate ☐ Higher (Please specify) ……………………………

Employment: ☐ Working ☐ Studying ☐ Unemployed ☐ Retired

What is your ethnic group? Choose ONE section A to E, then tick the appropriate box to indicate your ethnic group.

A: White ☐ British ☐ Irish

☐ Any other White background, please state ……………………………

B: Mixed

☐ White and Black Caribbean ☐ White and Black African ☐ White and Asian

☐ Any other mixed background, please state ……………………………

C: Asian or Asian British ☐ Indian ☐ Pakistani ☐ Bangladeshi

☐ Any other Asian background, please state ……………………………

D: Black or Black British ☐ Caribbean ☐ African

☐ Any other Black background, please state ……………………………

E: Chinese or other ethnic group

☐ Chinese ☐ Any other, please state ……………………………

Nationality (Please specify): ……………………………

Which country do you live in now? (Please specify): ………………... How long? ……..years

Which country were you born in? (Please specify): ……………………………

What is your first language? (Please specify): ……………………………

1
Appendix 13 (continued): Paper-based questionnaire

Please tick ‘Yes’ or ‘No’ for each exhibit, and complete the question that follows.
1. Have you ever used the Gravity Well exhibit before today?
   □ Yes      □ No

   Please explain the meaning of the word ‘gravity’ as you understand it at school.
   ____________________________________________
   ____________________________________________
   ____________________________________________

2. Have you ever used the Big Bang exhibit before today?
   □ Yes      □ No

   Please explain the meaning of the word ‘particle’ as you understand it at school.
   ____________________________________________
   ____________________________________________
   ____________________________________________

3. Have you ever used the Getting the Picture exhibit before today?
   □ Yes      □ No

   Please explain the meaning of the word ‘focus’ as you understand it at school.
   ____________________________________________
   ____________________________________________
   ____________________________________________
Appendix 13 (continued): Paper-based questionnaire

Post-test paper questionnaire

1. Please explain the meaning of the word, ‘gravity’ after you have used the Gravity Well exhibit.

How well do you understand the Gravity Well now?
☐ Not at all ☐ Very little ☐ Moderate ☐ A lot ☐ Very well

Please explain how it works in your own words?

2. Please explain the meaning of word, ‘particle’ after you have used the Big Bang exhibit.

How well do you understand the Big Bang exhibit now?
☐ Not at all ☐ Very little ☐ Moderate ☐ A lot ☐ Very well

Please explain how it works in your own words?

3. Please explain the meaning of word, ‘focus’ after you have used the Getting the Picture exhibit.

How well do you understand the Getting the Picture exhibit now?
☐ Not at all ☐ Very little ☐ Moderate ☐ A lot ☐ Very well

Please explain how it works in your own words?

3