Drawing and designing: an analysis of sketching and its outputs as displayed by individuals and pairs when engaged in design tasks

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Drawing and Designing: An analysis of sketching and its outputs as displayed by individuals and pairs when engaged in design tasks

by

Steven W Garner

A Doctoral Thesis

Submitted in partial fulfilment of the requirements for the award of

Doctor of Philosophy of Loughborough University

April 1999

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Poor text in the original thesis.
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Some images distorted
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Abstract

Drawing and designing have always exhibited a close relationship but this programme of research presents new knowledge regarding their interaction. The ability to model graphically, particularly via freehand drawing or sketching, is shown to provide a wide range of designers with a valuable and flexible resource for communication. More importantly, this thesis presents sketching activity and sketch output as significant to the cognitive processes of creative design development in individual and team working. Such new knowledge is urgently needed. Professional design practice - particularly industrial design practice - is shown to be experiencing dramatic changes. It is proposed that various commercial pressures, together with technological developments, have contributed to the phenomenon of computer supported collaborative working (CSCW). It is further proposed that the construction of suitable environments for what the author terms 'computer supported design teamworking' (CSDT), largely by those outside of the design professions, is hindered by a poor understanding of the functions and value of sketching.

This thesis presents a research programme of two projects. The first, sponsored by the National Society for Education in Art and Design (NSEAD), exploits a focused interview technique in an analysis of the functions of sketching in the creative synthesis, exploration, development and resolution of industrial design problems. The second project presents a close study of the sketching activity and sketch output of pairs of industrial design students. The Analysis of Graphic Acts (AGA) project (based on data produced in an earlier project entitled ROCOCO at Loughborough University) reveals significant differences in drawing activity between pairs of subjects collaborating proximally and similar pairs collaborating from remote sites via computer based tools. The analysis reveals a 30% decrease in overall drawing production by remote participants but a 51% increase in time making Graphic Acts. In spite of producing a 17% lower mean number of sketches, the mean number of shared sketches was 31% higher. There was an increase of 37% in Sketch Graphic Acts (SGAs) per sketch and 52% more SGAs were committed to shared sketches in the remote condition. There was a 31% decrease in the proportion of sketches with three or less SGAs (characterised as 'thumbnail' sketches). The work leads to recommendations for the design of future CSDT environments via a discussion of the sketching requirements of industrial designers.
Acknowledgements

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The research team involved in the ROCOCO project at Loughborough University between 1988 and 1992 - project leader Professor Steve Scrivener, Tony Clarke, Dr John Connolly and Andre Schappo, plus the research assistants Shaun Clark, Michael Smythe and Dr Hilary Palmen. Thanks go to the students of the Department of Design and Technology who took part as research subjects. Acknowledgement must also go to the Science and Engineering Research Council and the Department of Trade and Industry who funded the ROCOCO project, and to TDS Numonics for research support. The author is particularly grateful to Professor Scrivener and his staff at Derby University for access to the ROCOCO data which was revisited as the AGA project.

The National Society for Education in Art and Design (NSEAD), together with Berol Ltd., who funded the focused interview research described here. The author is particularly grateful to Tom Pannell, Professor Arthur Hughes, Dr John Steers & Ivan K Davies of the NSEAD for their assistance and support. Thanks must also go to the various designers who gave up their time for this research.

Thanks also to Briget Egan, King Alfred’s College, Winchester and Helen Hudson for their help with the manuscript and to Dr Diane Gyi for help with SPSS.
Notes on Style

This thesis is presented as five Sections, each divided into chapters. Section and chapter headings are presented in 14pt bold. Subheadings are presented in 12pt bold. Any further divisions are titled in italics. For the convenience of the reader each chapter heading page includes a copy of the respective chapter contents. Where emphasis is intended on particular words then italics or single quotation marks are used. A one-page summary concludes each section.

Two systems of referencing operate. One follows accepted conventions for referencing published material, that is, the author and date of publication are given in the text (eg, Garner 1999) and the full reference can be found in the reference section at the end of the thesis. A second referencing system has been included since some of the chapters refer to interview transcripts which are appended to the thesis. In this case a reference to the particular location in the transcripts is provided via a page number only. For example, a quotation followed by (A123) indicates that the reader will find that particular quotation on page 123 of the appended transcripts - the prefix 'A' indicating pages in the appendices. Long quotations are indented as a separate paragraph.

The appendices contain copies of a selection of the graphic output from the Programme plus examples of the data collection tools. A number of the graphs have also been appended to save space in the main thesis.
# Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AGA</td>
<td>Analysis of Graphic Acts project</td>
</tr>
<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
</tr>
<tr>
<td>CAID</td>
<td>Computer Aided Industrial Design</td>
</tr>
<tr>
<td>CAM</td>
<td>Computer Aided Manufacture</td>
</tr>
<tr>
<td>CMC</td>
<td>Computer Mediated Communication</td>
</tr>
<tr>
<td>CSCW</td>
<td>Computer Supported Co-operative (or Collaborative) Working</td>
</tr>
<tr>
<td>CSDT</td>
<td>Computer Supported Design Teamworking</td>
</tr>
<tr>
<td>DGA</td>
<td>Drawing Graphic Act</td>
</tr>
<tr>
<td>DTI</td>
<td>Department of Trade and Industry</td>
</tr>
<tr>
<td>GA</td>
<td>Graphic Act</td>
</tr>
<tr>
<td>HCI</td>
<td>Human Computer Interaction</td>
</tr>
<tr>
<td>ID</td>
<td>Industrial Design</td>
</tr>
<tr>
<td>IED</td>
<td>Information Engineering Directorate</td>
</tr>
<tr>
<td>ISDN</td>
<td>Integrated Services Digital Networks</td>
</tr>
<tr>
<td>NPD</td>
<td>New Product Development</td>
</tr>
<tr>
<td>NSEAD</td>
<td>National Society for Education in Art and Design</td>
</tr>
<tr>
<td>SD</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical Package for the Social Sciences</td>
</tr>
<tr>
<td>ROCOCO</td>
<td>Remote Collaboration and Communication project</td>
</tr>
<tr>
<td>WGA</td>
<td>Written Graphic Act</td>
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</table>
In 1984 the author was a new member of academic staff in the Department of Design and Technology at Loughborough University. There were significant and diverse opportunities for research. In the UK, design education at Secondary level had barely reached maturity and had yet to become established at Primary level. In Higher Education the phenomenon of ‘design research’ took many forms including practice-based research as well as philosophical and experimental inquiries. Significantly, ‘design’ had, by this time, become part of the vocabulary - or at least the rhetoric - of British business and industry. This was largely due to the activities of central Government via the Department of Trade and Industry and agencies such as The Design Council. However, its definition and application within the sector differed considerably. The 1980s was also a time of dramatic technological and economic change. Organisations demonstrated a heightened awareness of the need to establish a competitive edge in international markets and one of the key topics was the better use of resources. With regard to resources, two related phenomena stood out at this time. Firstly the rapid development of technologies for computing and communications and, secondly, the desire on the part of many organisations to facilitate improved teamworking. The design industry, particularly that represented by research and development activity in manufacturing industry and in product design consultancies, had a close interest in both of these phenomena and, potentially, it provided a market for new knowledge which addressed the particular needs of the design professions. It was a buoyant time to be beginning a research career. However, while there was clearly a market for appropriate new knowledge plus the opportunity to undertake research it was not at all clear what knowledge would prove to be appropriate. It was the character of the research culture in the university sector which was initially influential in establishing a research direction.

Although an explicit and broad foundation of design research had been established in the UK since, certainly, the 1960s the design research community was a small one. The early studies involved professions that were themselves still emerging and the findings were often based on small research projects. Investigation and understanding of the practices of design appear naive - even when compared to our incomplete
knowledge at the end of the 1990s - relying, as they did, largely on commentaries of tacit understanding by experienced practitioners and educators. It is worth noting here the simultaneous education-based research which made significant contributions to an understanding of design and designing. The 'modelling' processes of designing were clearly difficult to articulate but it was the limited amount of research into these internalised and complex workings which stimulated a broad interest in design research by the author. This was given a sharper focus at Loughborough via recurring questions regarding the functions and value of drawing and particularly 'sketching' in designing activity. There were also pertinent and timely questions asking why sketching merited a significant part of increasingly crowded design curricula?

Within design research, freehand drawing or sketching particularly suffered from a lack of theoretic underpinning. While the shelves of libraries and book shops presented comprehensive guides to the 'hows' of sketching very little appeared to address itself to the 'whys'- particularly for subjects outside of art education. It was curious that while sketching had formed a central skill in tertiary design education throughout the twentieth century (and much earlier in some cases) the development of design capability in general education was proceeding with little or no published work regarding the functions and value of sketching within design activity. It appeared that here was a unique field where the scale of the need for research was in marked contrast to the scale of the resources available. The author saw here an opportunity to combine an interest in the procedures of commercial design activity with the needs of design education in a research programme.

In 1987 an opportunity emerged to submit research proposals to the National Society for Education in Art and Design (NSEAD) under their annual bursary award competition. This was sponsored by Berol Ltd who each year offered a £1,200 bursary prize for a research and/or curriculum development bid in the field of art and design education. A rather humble research proposal titled 'Drawing and Designing' was submitted which proposed to investigate, via semi-structured interviews, the role of drawing and sketching for twenty individuals engaged in commercial design activity. The author won this bursary in the summer of 1987 and research interviews took place between August of that year and August 1988. It was a genuinely illuminative research project as befits the start of a research programme. There were few expectations regarding what was likely to emerge regarding drawing and its functions for a broad range of designers which included, amongst others, a theatre designer, an engineer, a silversmith and an architect. The questions were mostly open-ended and the interviews were allowed to follow directions suggested by the interviewees. It was an immensely valuable project and continues to be so. The findings together with the conduct of the research are discussed in detail in Section 3 of this thesis but for the purpose of this introduction it can be noted that the project not only provided the foundation to later
studies in the programme but it continues to be cited by eminent researchers in the field (see Archer, 1997, p39). So began the first part of the programme - one which was concerned with the functions and value of sketching for designers who operated both as individuals and within teams.

The programme of research had begun during a period of fundamental change in the design professions. Computer based working was becoming a necessity in a wide variety of professions and occupations within, for example, administration, government, medicine, transport services, tourism and manufacturing. There are numerous advantages to computer based working for many levels of commercial activity from individuals to multi-national corporations. These include potential for remote working and file sharing, convenience, cost, information processing and computer based communication. The design and design-related professions have been quick to identify that computer based modelling has distinct advantages over other modelling systems. Computer modelling allows individuals to easily generate and modify information; the input devices (the computer and peripheral equipment) are conveniently packaged and can be located almost anywhere; digital data are easily stored or transferred; sophisticated evaluation is possible at a fraction of the time and cost of some traditional methods; and computer models are compatible with modern management requirements for teamworking and simultaneous development.

The age of the 'heroic' individual designer has long since passed. Whilst there may be some people engaged in designing activity who work alone - such as some crafts people - for most design specialists, work will include collaboration with a wide variety of others. The range of knowledge required in most areas of design is simply beyond the individual - instances might include expert understanding of materials, manufacture, costing, marketing, human factors, and legislation. Because of this, most professional designing activity, from that based in corporations to that in consultancies, requires teamworking skills and the ability to share models. In the 1990s this is being supplanted by the ability to work creatively in multifaceted teams and implies not only a developed teamworking ability but the skills, temperament and facilities to jointly develop relevant models.

Computer based working became established very early in the design and design-related professions. They were in an ideal position to exploit new developments in computer based group working and this was accelerated by the pressures for teamworking highlighted above. In recent times computer based working has become associated with significant changes to the practices in business and industry, being at various times cause or effect. Its influence can be seen in new activities at all levels - from the factory floor to the boardroom. The influence of computer based working within the design industry and particularly in new product development has been

Introduction
considerable - not least because new product development now concerns all aspects of an organisation including research and development, production and marketing. Computer based communication, as seen in large corporations such as Boeing, was partly fuelled by the demands of organisations who required an efficient and flexible means of linking people together and partly by the technology push of rapid developments in computer technology and telecommunications. Computer based communication was built on the demands established through the telephone and fax technologies. Electronic mail (email) and other related tools supported group working but initially limited this largely to asynchronous working - the receiving of, assimilating and responding to information over a given period of time. There are some important reasons why asynchronous working might be very desirable - particularly for the design community and this aspect is developed in the work, but the search for a tool which facilitates synchronous or real-time working - and by implication a synchronous modelling capability - has proved very attractive to companies worldwide.

Thus both commercial pressures and technological developments combined to make fast, efficient communication available and essential both within and between organisations. Commercial advantage resulting from improved teamworking, better information and quicker development cycles was, and still is, the motivating goal for industry worldwide. It became clear during the NSEAD project that, in the context of modern design practices, an investigation of the sketching of individuals was of less significance than an investigation of sketching between individuals in design teams. This shift of emphasis was brought about partly by observations of commercial practice and partly by the statements of the interviewees in the NSEAD project.

In 1988 the author was invited by colleagues at Loughborough University to participate in the construction of a major bid to one of the Research Councils which proposed to investigate computer supported co-operative working (CSCW). The bid was successful and received £190,000 for a three year project of experimental studies which came to be known as 'ROCOCO' (from the words Remote Communication and Co-operation). The ROCOCO studies of CSCW provided the perfect opportunity to pursue an inquiry into the role of sketching for design teams - particularly sketching by computer supported design teams. The ROCOCO project consisted of two phases of research studies. Phase One consisted of studies of pairs of subjects who worked proximally on a given design task; that is, face-to-face and without computer support. Phase Two required similar pairs of subjects to collaborate on a design brief but this time they were located remotely from each other and linked by audio and video tools and a computer mediated shared drawing surface. Partly this inquiry was conducted within the ROCOCO project between 1988 and 1992 and the findings which emerged at the conclusion of the project are fairly attributed to the team involved. However, there has been a subsequent 'revisiting' of the data by the author in 1997 and this has
facilitated a new and unique contribution to knowledge concerning the functions and value of sketching within CSCW. Central to this revisiting has been the development of a process of Graphic Act analysis as a means of defining important differences between sketching activity of computer supported remote pairs when compared to similar studies undertaken with proximal subject pairs. This research is referred to as the Analysis of Graphic Acts (AGA) project in order to distinguish it from the earlier ROCOCO project which provided the original studies. This is presented in Section 4. It is proposed that computer supported design teamworking (CSDT) is an increasingly important element of CSCW. Furthermore, a greater awareness of the functioning of sketches and sketching within CSDT systems is required if they are to meet the requirements of the design professions.

Although they employed very different research strategies the ROCOCO/AGA project and the NSEAD project assist the definition of the complex functioning of sketching where designers are collaborating with others. The functioning is partly concerned with communication between team members but, perhaps more significantly, the research programme highlights the role of sketches and sketching in support of cognitive processes concerned with the creative manipulation of ideas.

CSDT research is a subject which can only increase in importance in the decades ahead. Local computer networks within design organisations are important but they have already been supplemented by international networks - mirroring initiatives in other professions such as medicine and higher education. CSDT would appear to be unique within CSCW in its demand for and exploitation of a drawing interface. More particularly, CSDT appears to require, more than other applications of CSCW, a sophisticated means of supporting sketching activity between participants. The creative stages of designing (which may repeatedly occur throughout a given example of design and development) particularly appear to rely on sketched pictorial imagery for the communication and development of the problem space, creative interpretation of information and the support of emerging ideas. They are also stages where many and varied contributions are expected. They are vital stages in all new product development and much investment rests on the quality of their support procedures and output.

Designing has become an international activity and international communication is an expected part of many designers' skills. However, little research exists which informs the functioning of remote and virtual design teams - temporary constructions of groups of designers and other specialists involved in new product development (NPD) and who may be located considerable distances apart. More particularly, little research exists which highlights the important contribution of sketching in synchronous and asynchronous collaborative work between remote designers.

Introduction 5
A Diagrammatic Representation of the Subject Matter

This thesis is derived from a programme of research into sketching undertaken at various times between 1987 and 1997. The structure of the thesis, presented as five sections, facilitates the communication of the two projects which make up this programme. The character of the research inquiry can be represented by a simple model comprising of two superimposed figures (Figures 1.1 and 1.2). These are discussed separately and then combined as Figure 1.3. The figures facilitate the presentation of distinctions between sketch attributes, sketch functionality and the conditions in which sketches are made and are founded on two observations:

i. Sketching requires a drawer or 'agent' of the activity, and it requires a 'viewer'. At some points in any given design activity the agent and viewer may be one person; at other times in the same activity there could be many agents and many viewers.

ii. A designer, acting as agent, undertakes sketching activity and produces sketches for their own perceived needs. They act to determine the functionality of the sketches. However, sketches have attributes of which only some may be intended by the agent. This is potentially problematic since attributes are partly determined by the agent and partly by the viewer(s).

![Diagram](image)

**Fig 1.1** Diagrammatic model representing two broad areas of intended functionality for sketching undertaken within design activity: the left concerned with 'internal', developmental functions and the right for 'external', communication-related functions.

Figure 1.1 seeks to present a distinction in sketch functionality between broadly personal or 'internal' functions and those which are associated with communication and may be termed 'external' functions. Both of these functional types may be employed at
many points in any given example of design activity - each giving rise to particular types of sketch output. Internal sketching functionality is required when an individual designer operates as both agent and viewer. In this case sketching may be seen to support personal cognitive processes and it may have an important relationship with creative and analytical processes. Thumbnail sketches or speedily drawn doodles might be a typical output. They may not be intended to be shown to any other person; that is, they may have no explicit communicative function, but nevertheless they are generated in a personal process of internalisation, representation, evaluation and development. External sketching functionality is required when a designer attempts to communicate graphically with others involved in the process. This type of functionality underpins the need to employ drawing conventions and the output can be distinctly different to the former type. A central research question for the NSEAD project concerned the extent to which designers value and exploit both of these functional capacities of sketching in design activity and this is explored in Section 3. The tessellated boundary lines in the figures is intended to represent the absence of a clear division between the areas of each model.

Figure 1.2 presents the other half of the research model which represents the graphic act analysis undertaken via the ROCOCO/AGA projects.

---

**Proximal / Synchronous**

Pairs of student designers working collaboratively face-to-face and with pen and paper so as to resolve a shared design task in a set time

**Remote / Synchronous**

Pairs of student designers working collaboratively but remotely located and linked by computer mediated tools for communication and design in the resolution of a shared design task in a set time

---

Fig 1.2 Diagrammatic model of the Analysis of Graphic Acts (AGA) project. It represents two areas of research into sketching in collaborative designing: the upper concerned with 'proximally' located participants and the lower concerned with remotely located participants.

As with Figure 1.1, Figure 1.2 displays two sides - this time divided by a horizontal tessellated line. The upper half represents face-to-face or 'proximal' teamworking.
which, in this programme, means studies of sketching activity and sketch drawings produced by pairs of design students who were collaborating proximally on a shared design task. That is, they worked together in the same room, sharing one large pad of paper on a large flat topped desk. This may be viewed as representative of a 'traditional' teamwork situation where participants can physically interact through discourse and gesture as well as via sketching. The area below the boundary line represents 'remote' designing activity and, more particularly, the exploitation of sketching in remote design activity. In the programme it comprised pairs of student designers who were located in different rooms but who were provided with computer-based tools to support their task of resolving a shared design brief. This is discussed in detail in Section 4.

When one superimposes the two models presented as Figure 1.1 and Figure 1.2 one achieves a crude functionality/activity model of the structure of the research programme. It also highlights some of the guiding issues in the research. Figure 1.3 presents the combined model.

![Diagram](image)

Fig 1.3 Diagrammatic model representing the research inquiry and presenting a matrix of four areas of concern for research into sketching in collaborative designing.

The top right quarter represents research into the communicative functions of sketching. This is probably the least controversial and easiest field to understand and it has seen the most research activity in recent decades. Even the non-specialist would appreciate that sketching can support communication in face-to-face meetings and Section 1 summarises relevant published work in preparation for related findings in the NSEAD project.

Introduction
The top left quarter moves into less well researched and less documented territory. This concerns the exploitation of sketching as a personal developmental tool. The NSEAD project is helpful in illuminating its exploitation by a wide variety of individuals in a number of contexts. Both the NSEAD project and the AGA project illuminate the integration of internally-oriented drawing strategies with the exploitation of externally-oriented communication strategies. Analysis of the personal use of sketching, by individuals and those operating in teams, is less common and would be one area where this work would claim to make a contribution to knowledge.

The lower right quarter of Figure 1.3 represents research into the use of sketching for communication where participants are located remotely from each other and linked by computer based tools. This is a relatively new field but there has been significant research activity because of the tremendous growth of computer based working in recent decades. There has been a growing demand for research which will lead to improvements in computer based working practices, particularly computer mediated communication (CMC), and this has not arisen solely from the design professions. An ever increasing range of professions involve CMC such as finance and banking; in the motor and oil industries; and in travel and medical services and this demand has fuelled research into such areas as teleconferencing, networking and multiple file sharing. However, the design professions have provided a big stimulus to research into the exploitation of sketching as one of the tools of CMC. The NSEAD project and the AGA project together provide an important review of the functions and value of sketching in computer supported design teamworking and the findings may well have applications in other professions.

The lower left quarter of Figure 1.3 is, without doubt, the least explored aspect of drawing. This quarter represents research into the exploitation of sketching to support internalised, personal capabilities within computer supported design teamworking. In this programme it takes place within pairs of remotely located design students who are connected by headset telephone, shared computer-based drawing surface and a video link to their partner. The internal functionality is partly illuminated by the NSEAD project and concerns creative strategies (for example, the generation or interpretation of ideas), developmental strategies (for example, personal evaluation and improvement), and other strategies associated with a personal capacity for conceptual modelling. This quarter represents that research in this programme (particularly via the AGA project) which sought to examine both the personal use made of sketching and, for both individuals within a pairing, the relationship between creative and communicative strategies as manifest in computer supported design teamworking. Once again the author would claim to be able to make a contribution to knowledge via the research represented by the third and particularly the fourth quarter of the model depicted in Figure 1.3.
This thesis aims to present a contribution to knowledge regarding the functions and value of sketching for the design community. It seeks to establish our current understanding regarding the functions of sketching in creative work with particular reference to the industrial design community. The findings are integrated and applied to new and emerging technologies in order to guide the developers of future systems. It is intended that future environments for computer supported design teamworking will better support the richness, quality and functionality of sketching for industrial designers.

A map of the thesis is presented as Figure 1.4. The NSEAD project and the ROCOCO/AGA project are given their own sections (Sections 3 and 4 respectively). An appropriate beginning to the thesis has been less easy to determine. There is little in the form of an accepted research foundation in drawing and sketching on which this research could be based. If anything, the subject field is characterised by some good but specific research work, many omissions and a good measure of disputes. However, this is turned to advantage in Section 1 where an accurate picture of the field can be presented under the heading 'Perspectives in Drawing Research' with contributions from fields such as art, education, psychology and engineering. This provides the reader with an insight to the context of themes and issues within which this work should be read. A discussion of methodology appears in Section 2.

Fig 1.4 Map of the thesis.
Section 5 returns to the principal themes and reviews the significance of what has been achieved. The conclusion of the thesis seeks to explore the current and future commercial application of CSDT. It presents opinions from members of leading-edge manufacturing industry including Black & Decker and Motorola plus leading-edge consultant designers, and it highlights potential future research directions.

**Alms and Objectives**

The programme has taken place over a ten year period and, understandably, the aims and objectives have developed during this time. More particularly, each of the two projects presented in this thesis have their own distinct aims and objectives. At the outset of the programme the future direction was unknown and hence the need for the illumination sought via the NSEAD project. However, it is possible, with hindsight, to identify a loose set of aims and objectives for the overall programme but each project description (Sections 3 and 4) includes the specific aims, objectives and conclusions pertaining to that work.

**Programme Alms**

* To bring about new knowledge concerning the exploitation, functioning and value of sketches and sketching activity for professional designers and design students operating individually, in pairs and in larger teams - particularly, but not exclusively, in the field of industrial product design.

* To illuminate the practice of sketching within the emerging phenomenon of computer supported design teamworking and to analyse the ability of a particular collaborative system to support sketching where participants are located remotely and linked by computer based tools.

* To produce evidence on which to justify the continued development and/or inclusion of the teaching of design sketching in increasingly crowded design curricula in schools and higher education.

**Programme Objectives**

* To undertake a literature survey and focused interviews with respect to drawing and designing so as to illuminate the research field, determine research parameters and to establish a detailed research agenda.

* To explore terms and definitions associated with sketches and sketching activity; to document the functions and value of sketches and sketching for a wide range of professional designers; and to interpret current thinking regarding the cognitive processes associated with design sketching - particularly in the

*Introduction*
creative stages of designing.

- To establish the reasons underpinning the emergence of computer supported design teamworking and to discuss the likely importance of sketching within this.

- To devise and undertake studies so as to be able to identify any significant differences in sketching and sketch output between pairs of design subjects located face-to-face, and using pens and paper, when compared to similar subjects located remotely but linked by audio, video and a shared computer based drawing facility.

- To make recommendations concerning the likely sketching requirements of designers if systems for computer based communication are to be effectively used to support remote, synchronous, collaborative design activity.
Section 1

Perspectives in Drawing Research
Chapter One

The Context of Research into Drawing

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1.1 An Interest in Sketching

Drawing may be viewed as one of the most basic and ancient abilities of the human race. The functions of drawing have developed over time and in recent centuries drawing has become identified both with leisure and with distinct professional activities such as designing. More recently still, it has become a subject for research, rather than merely a central part of the means of practising.

The nineteenth century saw a marked increase in interest in preparatory drawings - particularly those of artists. There may be many reasons for this: the wider availability of drawings via improvements in publishing; the influence of new sciences such as psychology; a democratisation of the arts and sciences and an awareness of a 'process' of creativity each may have contributed to an increased interest in the freehand drawings and sketches of various specialists. While much sketched output may never have been intended for the eyes of any viewer other than the drawer it is this very aspect which provides value. It appeals to our voyeuristic character, promising insight into the mind of the drawer. The status of preparatory work, particularly sketches on paper, has been enhanced during the twentieth century and, today, interest in such work by public and professional communities is immense. There have been a number of events in recent years which highlight the widespread interest in sketching activity and output. In 1989 the British Museum organised a major exhibition and conference entitled Drawn, Art and Development; in 1993 The Design Council gave over their Haymarket premises to an exhibition entitled Drawing Up Ideas; and in 1995-96 the Victoria and Albert Museum organised an exhibition and conference entitled Back of an Envelope. Many of the displays presented very early, conceptual ideas, in sketch form, of familiar items of our consumer culture such as household appliances, cars and personal products. All three exhibitions opened to critical acclaim and recorded good public attendance figures.

Up to the 1980s there was a very small community of researchers who were actively engaged in studying and publishing analyses of drawing and sketching within design activity. By the mid 1980s the drawing research community had made significant contributions to the theoretic knowledge of drawing - and particularly sketching - that both derived from and informed practice. In the early 1990s, with the birth of the 'new' universities in the UK from the old polytechnics and colleges of art and design, research in art and design was invigorated. Sketching was one of the subjects which attracted research interest. It is also worth noting that the Research Assessment Exercises in higher education have exerted a certain pressure to externalise research activity in particular ways and there has emerged in recent years a number of new journals and conferences which have assisted the promotion and dissemination of art and design research including studies of drawing and sketching.
1.2 The Need for Research into Sketching for Designing

The demands for clarification and development of the roles of drawing within design have long been voiced but rarely met. In a short article in Design magazine in 1979, Phil Gray, then Design Group manager of Loughborough Consultants observed:

...the skill of drawing is so low on the list of priorities in design education that people now have to be reminded that drawing is, after all, a fundamental element in the design activity. (p76)

Colin Tipping (then of Middlesex Polytechnic) echoed this view in the 1980s stating that a fluent sketching ability is ‘...the single most important factor in developing any general design ability’ (Tipping 1985). However, as we approach the end of the century, evidence arising from research into this important activity remains thin on the ground. It has been nearly twenty five years since Bruce Archer proposed his three language model of education in which a competence beyond numeracy and literacy was identified. In his paper The Three R’s (1976) he presents a new approach to knowledge and a manner of knowing which is distinct from those of Science and Humanities:

Where Science is the collected body of theoretical knowledge based upon observation, measurement, hypothesis and test, and the humanities is the collected body of interpretive knowledge based upon contemplation, criticism, evaluation and discourse, the third area is the collected body of practical knowledge based upon sensibility, invention, validation and implementation. (Archer 1976)

In the same paper Archer identified drawing as a fundamental component of ‘modelling’ and proposed that modelling was the ‘language’ of this broad third type of human capability which he termed simply ‘Design’. While the term ‘graphicacy’ appears in many publications of the time (see, for example, Brazil, 1975; Boardman, 1982) in various attempts to promote drawing as a particularly valuable mode of modelling and representation, there was little rigorous research into the relationship of drawing to the modelling of ideas by designers or design educators. Perhaps it is the immense scope of drawing that stifles a clear articulation of its functions. Not only can it be employed to communicate precise intentions (for example, via the conventions of engineering drawing), but it can convey mood and feeling through a process of interpretation. It may be exploited at the very earliest conceptual stages and as a final act in the design process. Between these extremes, drawing can provide a profound and diverse resource.
If there has been any 'tradition' of drawing research as implied in the Introduction then this too has been unbalanced and subject-specific. The Fine Arts, particularly, may rightly claim a long tradition of practice-based research through drawing. Within this field there has been a smaller but equally respected tradition of research into drawing. This has tended to view drawing as output or product. However, knowledge resulting from research into drawing as an activity, that is as process is, at best, patchy. This state of affairs is all the more depressing since new technology presents us with significant new opportunities to exploit graphic imagery and to harness our graphic skills. If the opportunities are to be realised the users and, more importantly, the developers of the systems need to have an adequate grasp of the nature and scope of the relevant issues concerning drawing.

As a result of dramatic increases in computing power, even the most basic personal computers are now able to present and manipulate complex graphic images. Consequently there has emerged, particularly since the 1980s, a growing interest in the graphic and visual aspects of computer science. A small but significant element of this has been the establishment of a research community concerned with investigations of the role of drawing, and particularly freehand sketching, within design activity. It would seem that one of the main motivational forces for this research has been the desire for an improved operational competence with new technological advances in communication. Information technology facilitates new working practices and a vast array of information sources has become available to individuals via their own computers. Equally importantly, teams of people can now be brought together via sophisticated teleconferencing environments eroding organisational and geographical boundaries. The design professions have been quick to realise the potential for such technological advances but little research exists which documents the particular graphic requirements of this work and which might lead to appropriate support systems. It is not merely a case of supporting communication as some manufacturers would have one believe. Design activity is a creative activity and systems which purport to support teams of designers who may be located a considerable distance apart need to facilitate such creativity in addition to communication.

Researchers and research groups around the world are beginning to establish new knowledge concerning the subject of sketching and some of the important developments are explored in this section. More importantly perhaps, research is beginning to identify the boundaries to the domain and to highlight important new relationships with related subjects. The development of a new level of sophistication in computer based resources will require good quality information from well designed and rigorous research activities. Research studies into the manifestation of, and relationship between, drawing and designing are now more urgent than ever.
Research into drawing is a young subject. Its procedures have been adopted and adapted from other research fields. Part of its knowledge base has come from other disciplines including neuroscience and child psychology. Other 'knowledge' exists as conjecture, including the subjective opinion of experienced practitioners and interpretation of the findings of particular, and often small scale, studies by researchers. This is not to devalue such knowledge but reflects, rather, an attempt to present an accurate picture of a research community still seeking to establish a shared understanding of, for example, the value and appropriateness of research methods, the boundaries to the domain and its relationship with other domains. It is a research community distinguished by its disputes over subject perspectives and research issues as much as its shared knowledge. The foundation of this research programme was established in the context of certain important perspectives apparent in the research community. Three key perspectives are presented in this section. They concern:

i. our current understanding of how drawing and sketching works
ii. the functionality of drawing and sketching as modelling within design activity, and
iii. the changing nature of design practice.

Some of the issues resulting from the perspectives are perennial while others are new or have emerged recently. In order to explore these perspectives it is necessary to establish definitions to terms. This is itself no easy matter and Chapter One continues with a review of pointers in a search for workable definitions.

1.3 Attempts at Defining Drawing: Activity and Output

Modern knowledge of drawing has arisen largely within a context of social democratisation and mass communication. Such knowledge is as likely to be the result of public or common interpretation as much as a result of scholarly inquiry. The process has facilitated the establishment of considerable variety in opinion and knowledge - not least in the terms used to describe both the 'activity' of drawing and the 'output' of drawing. Any attempt to construct a meaningful hierarchy of terms or a taxonomy of drawing is hindered by the idiosyncratic language in common usage and the lack of widely accepted definitions within the research community. The art and design professions seem to operate with terms which have a considerable level of interchangeability - even within individual specialisms. Output may be referred to as drawings, sketches, visuals, renderings, roughs, etc. There have been a few attempts to define a drawing taxonomy (see Schenk 1991) but the lack of agreement is a serious problem which hinders the research community in this field.

It is the scope of the activity of drawing, as much as the variety of outputs referred to as drawings, that has given rise to difficulties in a search for a robust definition. The
Collins English Dictionary provides clarification on forty-one uses of the verb 'to draw'. Whilst it includes "... to depict or sketch as with a pencil or pen", it also, interestingly, refers to "... choosing at random, shaping, and attracting". Philip Rawson produced a seminal text on the subject in 1969. In his book, *Drawing*, he establishes a useful marker in a search for a definition:

Drawing I take to mean that element in a work of art which is independent of colour or three dimensional space, the underlying conceptual structure which may be indicated by tone alone. (Rawson 1969 p1)

Even this rather focused and particular definition allows a great deal of human activity to be viewed as drawing but Rawson's concentration on drawing within works of art fails to stimulate the examination of drawing as a rich and commonplace resource. A further helpful pointer was provided in the early part of the twentieth century by Vernon Blake, the English artist. He states that:

Drawing is a loose term to which we must accord at least two meanings. It consists first of all in a perfect comprehension of the structural nature of objects; and secondly in the power of expressing thought and emotion by means of writing down of such structural nature. (Blake 1927 p30)

Edward Hill, in his presentation of studies of drawing from the Fine Arts, offers comment on lesser known drawings including preparatory studies and sketches and in doing so begins to uncover a richness of the subject. Taking the activity of freehand drawing as a means for increasing one's perception, Hill presents a considered appeal for further study of graphic imagery within design activity. He presents a concise and considered definition which highlights the process of drawing as much as the product. He states:

Drawing is the act of making a mark, line, or incision on a surface; and in the larger sense, a participation in the language of Drawing. (Hill 1966 p8)

The comparison of drawing with natural language has been explored by other researchers and there would now appear to be some agreement that the cognitive mechanisms for speech and visual processing are closely related. This is further explored in Chapter Three. The notion of drawing as a language has never really been subjected to rigorous and analytical dissection in the way that the linguist's domain has. The researchers of drawing have, for the most part, satisfied themselves with allusions and comparisons to the defined structure of natural language. Rarely has anyone attempted a codification for drawing to the extent of a grammar or syntax. Evidence is either anecdotal or incomplete.
Rawson extends his analysis by presenting drawing as 'the most fundamentally spiritual - i.e. completely subjective - of all visual artistic activities' (Rawson 1969 p1). He argues that nowhere in nature are our eyes confronted by lines and the relationships between lines which he presents as the raw material of drawing. However, if drawing has a profound relationship with subjectivity then what can we make of its potential for objective information? Ian Simpson presents cartographers' maps and engineers' illustrations as examples of the controlled communication of information through graphic means. Indeed, he goes on to state that the conveyance of information is a feature common to all drawings (Simpson 1957 p9). Clearly such a capacity of drawing to embrace the seemingly tangible in addition to the spiritual assists a search for definitions by highlighting a breadth to the functionality of drawing.

1.4 Functionality in Drawing

It is a strange paradox that while drawing is one of the most primitive of capacities of the human race, its functions and value remain a subject for debate. Evidence of its application can be seen in all periods of human development from the cave painting of prehistoric cultures, through ancient civilisations to our modern technological society and yet a clear understanding of the contribution which drawing makes to our existence eludes us. The lack of an agreed terminology for various graphic acts and graphic output is likely to have had an influence in this. As noted above, any definition of drawing has to acknowledge drawing as both process and product and as such has to acknowledge a relationship with human cognitive capacities. The artist Michael Ayrton noted in 1959 that:

> The process of drawing is before all else the process of putting the visual intelligence into action, the very mechanics of taking visual thought. Unlike painting and sculpture it is the process by which (artists or designers) make clear to themselves, and not the spectator, what they are doing. It is a soliloquy before it becomes communication. (Ayrton quoted in Fish 1997 p23)

The functionality of drawing as process is distinctly different to the functionality of drawing(s) as output. These two types operate in various human activities but are particularly important to design activity which requires integrated support for *internalised* cognitive processes such as analysis, exploration, development and evaluation and *externalised* processes such as communication. The former is the least researched capacity and is explored later in this section. This latter capacity, concerning the ability of drawing to support communication between the agent of drawing and the receiver, is more generally appreciated and can be concisely reviewed here via an examination of the work of Ashwin. It is the quality of the integration of the functionality which is important and which must guide a definition of terms.
1.4.1 Drawing and Communication

Perhaps the most accepted and readily understood capacity of drawing is its ability to convey information from one person to another. A wide range of human interaction - and particularly design activity - relies upon successful communication for the identification of requirements, the sharing of ideas, the confirmation of understanding and the evaluation of proposals. It is because of this profound ability of drawings to contain and convey a wide variety of information that numerous authors have adopted this as a focus for inquiry to the detriment of other capacities. One of the better analyses of the communicative functions of drawing within design activity is provided by Clive Ashwin (1984) who identifies six functions:

i **The referential function**: the imperative to inform the receiver (client, colleague etc) in a precise and unequivocal manner in which every effort is made to eradicate alternative readings and ambiguities in the encoded message. Typical of this type of drawing are the engineering systems such as orthographic and axonometric projections which present a particular type of resemblance to the object they seek to convey. Ashwin refers to architecture in highlighting that even though such images may be carefully codified they may contain some personalisation where symbols allow it. Essentially this type of drawing presents a rationalisation and an idealisation of the subject whether this be a building or an artefact.

ii **The emotive function**: where the situation requires it drawing can be exploited to convey emotive qualities, operating via the perceptual mechanism of the viewer. Ashwin cites contemporary fashion illustrations which deliberately distort physical characteristics in order to convey emotive qualities such as style and elegance. The rules are flexible, dynamic and fugitive - drawings change as fashion changes. Interestingly, Ashwin contrasts Victorian fashion drawing with its contemporary equivalent. The former, he proposes, exhibits a highly referential function where viewers demanded (and could see) precise information regarding shape, cut and detail. The emotive function is also seen in craft, graphic design, product design and architecture where contextual mood and feeling may be held to be of greater importance than some physical details - particularly where such details do not add to the 'desirability' of the subject. This function has not been lost on the marketing departments of organisations around the world who have exploited this capacity of drawing to show products in their best light.

iii **The conative (or injunctive) function**: this concerns the capacity for drawing to persuade - that is, act upon the information or perceptions gained via drawings (particularly emotive drawings referred to above). The desired action is typically the purchase of the subject in preference to others whether this be health and beauty

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products, foodstuffs or consumer products. Ashwin distinguishes conative from emotive with reference to the strategies which guide the graphic activity. While the conative force of a drawing may be intended to be emotive it may not be genuinely emotive with respect to the drawer. Some designers are required to produce images which are beguiling for the audience while repugnant to the drawer. Ashwin uses this to highlight a distinction between drawing for design and drawing in fine art activity. ‘The cognitive function must always harmonise with an artist’s emotive aspirations: a fine artist who draws in a certain way because it made his work saleable rather than because reflected his emotional condition thereby moves into an area of activity more akin to advertising design than fine art’. (Ashwin, 1984, p18)

iv The poetic or aesthetic function: While communicative drawing for design always has an instrumental purpose it may also exhibit a poetic or aesthetic function. This may not have been intended but can be perceived by the viewer. The carefully constructed and rendered drawings of the engineers Boulton and Watt or the original artwork for a major film production such as Jurassic Park may possess an aesthetic (and commercial) value well beyond the original value of its referential and/or emotive purpose. Such a phenomenon is usually restricted to some later time when the significance of the drawing adds to its graphic qualities. Ashwin explicitly denies that self expression or a focus on the intrinsic beauty of drawings and the drawing act have any place in communicative design drawing. He views these as the domain of the fine arts. But that is not to say they do not make an important contribution to designing where other objectives, outside of communication, operate.

v The phatic function: Ashwin takes the notion of phatic communication from the domain of the linguist and proposes a graphic equivalent for the initiating, maintaining, redirecting and concluding of communication. He cites comic illustration as a prime example whereby a rich system of graphic motifs is used and readily understood to capture and direct the attention of spectators. To what extent such a complex semiotic code is employed in freehand drawing is debatable but it has implications for an investigation into the use of such drawing in situations where two or more designers are collaborating on a shared brief. The parallels between phatic communication in natural language and the existence of a graphic phatic capacity would seem to be a relevant subject for analysis in studies involving multiple modes of communication between subjects engaged in collaborative design activity.

vi The metalinguistic function: Ashwin concludes his list with metalinguistic communication by which he means communication to comment upon, explain, clarify or qualify other communication. Such a function may give rise to drawings ranging from simple marks - for example, to highlight a particular image - to complex drawings relating to, but separate from, other (usually chronologically earlier) images.

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Metalinguistic functions may concern the communication of the context in which a particular image should be read or may take the form of additional information to clarify understanding.

1.4.2 Drawing, Seeing and Interpretation

The relationship between drawing and seeing has provided a rich vein for researchers. Bruce Archer has concisely stated that:

"Drawing is learning to see. Drawing is learning to look. To draw what you see is the first step towards the understanding of form, proportion and structure, not only in the tangible but also in the abstract. (Archer 1997 p39)"

As an accompanying element to his television series *Seeing through Drawing*, Philip Rawson produced a valuable book. In the introduction to this he presents the following analysis:

"Children's drawings illustrate very powerfully the fact that what we are able to 'see' in the world - not only things and facts, but quite subtle relationships of movements and personal response - depends very much on what we 'know' is there to be seen. Not only that, but even our being able to see some part of the world as a 'whole', with things organised within it, can depend upon our having learned to see the whole that we know should be there. So one vital function of drawing as we grow up is to help us to learn how to see." (Rawson 1979 p8)

Although Simpson initially appears to support this view it is clear that he values a particular quality of seeing for its effect on drawing capability: "...although most people can ...apparently see very well, they see in general terms and not in the specific way which is necessary for drawing" (Simpson 1987 p10). This is perhaps understandable given the didactic nature of his publication.

Rawson presents seeing as equally important to drawing but extends the debate to include much wider human capacities concerning the creation of symbols. Clearly drawings are not, and cannot be, exact records of things seen. They are composed of constituent parts, such as lines, which are determined by the draftsperson and, as such, the images are made up from elements that no one can 'see' in any object. The foundation of Rawson's proposition concerns the existence of a symbolic language of drawn lines and marks that are used by artists (and designers) to denote outline or separation of one plane from another in their work. If the language of drawing is to be used to facilitate communication then the viewer must comprehend, if only in part, the symbols used in the realisation of the image. The nature of the prevailing environment..."
will play a role in defining the acceptability and use of such a symbolic, graphic language simply because the artist and the society in which the artist operates share the same constructed reality. It is for this reason that it may be possible to isolate a number of languages - or at least differing use of symbols - within drawing, each operating in its particular time and each to a greater or lesser extent a response to its society. It seems likely that all children, from a very early stage, make drawings as a means of ordering their world; of making it intelligible. Whether it be with a paint brush or crayon they project, out onto a surface, images from inside themselves that are the result of perceptions and memories. Rawson describes a process of 'objectifying' whereby children create symbols for what is important to them or according to what constitutes truth for them. Whilst these images reveal a relationship with things distinguishable by natural language they are equally a personal version of the symbol. That is to say, whilst a child may understand the words 'house' and 'cat' and may be more than able to construct a symbolised, graphic representation from the word, the drawing will differ in certain respects from other children's work. While some personalisation may result from the development of different skills or controls it seems that different interests, perceptions or exposure result in each child adapting the symbol to reflect a more personal truth. In their analysis Hill, Rawson and Simpson support the view that drawing is a product of an interaction between personal feelings on the one hand and the relationships and basic concepts of a symbolised language on the other. It is a phenomenon that appears to be clearly observable in the work of children but its influence in the more mature mind has been much less investigated and is much more difficult to discern.

Hill reinforces this inter-relatedness of elements within the drawing process. He stresses the role of the psyche, operating in unison with technique in the construction of a drawing. Through an analysis of a study by the artist Modigliani he refers to a 'binding together of a personal sense of gesture and an individual response to experience' (Hill 1966 p5). In his analysis of the drawing, Hill appeals for our sensitivity to the nature of Modigliani's vision and the ideas that involved him in the work. He refers to pace of line, fullness and tonality in support of his appeal to base understanding and appreciation on more than mere technique.

1.4.3 Drawing as a Creative Facilitator

At the level of a creative facilitator, drawing can be seen to provide many of the same benefits to those engaged in design as it does for the painter and sculptor. Kirt Wirth extends the relationship between drawing and seeing and in doing so develops the definitions:

When we draw, we see everything more penetratingly. We distinguish essentials
from non-essentials, greatness becomes greater and smallness smaller. Anything which does not contribute to the incipient concept is left out. The limits of the picture space are determined and this is divided into tension fields of the active and the apparently passive parts of the picture. Events and experience also play their part in the alteration between sight and creative thought. In this way, what has been perceived is concentrated into a drawing. (Wirth 1976 p10)

Wirth clearly identifies drawing (observational drawing as well as drawing from memory) as an extension of an active, constructional capacity of the mind, but he extends this to discuss his interpretation of the role of sketching in the manipulation of information and its relationship to embryonic conceptualisation. Wirth perceives a constructive conceptual mechanism, intimately associated with freehand drawing:

Shapes arise from shapes and one develops from the other. The last-drawn lines give the idea for the following ones. The forms are partly very close to our conception and they become the criterion for the rest. We follow a vision, a hypothesis which changes because of what has already been produced. So we write and read simultaneously and follow a rule of the game that becomes more and more complicated. (Wirth 1976 p10)

The notion of freehand drawing or sketching assisting mental processes such as perception and the development of ideas is not unique to Wirth. Bruce Archer refers to drawings as 'external representations of something in the “mind’s eye”' (Archer 1997 p39) and he goes on to propose a three-cornered relationship between reality, one’s comprehension of that reality (a cognitive model) and one’s external representation of that comprehension (in this case, a drawing). The operational mechanism of this three-cornered relationship, particularly in relation to freehand drawing is explored in Chapter Three.

Drawing research has been fed by other, more particular, studies into the physiology and functioning of the human brain. The cognitive science community has provided much illumination. Research findings have facilitated an understanding of mechanisms which support cognitive modelling and this in turn has assisted the design research community to address the issues concerning ways in which drawing supports creative and analytical processes. The semantic issues of definition embedded in an investigation of what is sketching have turned out to be less important than investigations of how sketching (as an activity) and sketches (as output) work - particularly in the light of recent research from the cognitive sciences. The following three chapters return to the perspectives which were identified in 1.1. Chapter Two explores sketching as a component of drawing and reviews our current understanding of the significance of sketching activity and sketched output.

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# Chapter Two

**Perspectives on How Sketching Works**

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2.1 Sketching and the Mechanism of the Mind

Jonathan Fish, in his PhD thesis entitled *How Sketches Work* (1996), states, in his definition of terms, that:

Sketches are representations used to assist in the visualisation and mental manipulation of some unfinished or imaginary object (and) Sketches are drawings, colour studies or illustrations which possess the attributes of untidiness, incompleteness and ambiguity (and) Sketches are representations used to assist in the creation and experimental manipulation of an unfinished or imaginary object. (p25)

In his definition all sketches are also drawings but only some drawings could be termed ‘sketches’. The terms ‘drawing’ and ‘sketching’ have for some authors been synonymous but Fish pares away some of the conflation so as to examine the phenomenon of sketching in more detail.

Fish highlights a possible relationship between sketch imagery and a more primitive survival mechanism. He proposes that the indeterminacy or vagueness of sketches exploits a capability of the human brain to make sense of incomplete information. This mental capacity, he argues, is a cultural adaptation of a visual mechanism which would have allowed our ancient ancestors to make sense of and respond to confusing or incomplete stimuli from immediately present objects and events. He goes on to propose that sketches are cultural inventions which can mimic aspects of such stimuli in order to allow us (artists and designers) to exploit this mental capability for the different purpose of imagining objects which do not yet exist. Also, he links the physical mark-making act to cognitive mechanisms of the mind and proposes that ambiguity may have a positive and deliberate function in some types of drawings - namely sketches. (Fish 1996)

An examination of any collected works of sketching, executed by competent and practical hands, reveals the activity as an active rather than passive one. It is perhaps the most easily overlooked observation that sketches are the results of a physical process - one may almost say ‘performance’. Hill discusses this notion of performance in his detailed analysis of the execution of Chinese brush calligraphy. He proposes that the marks retained on a drawing surface are symbolic of the act that produced them and he goes to great lengths to demonstrate their construction as a dynamic affair (Hill 1966 p5). However, this dynamism involves concepts beyond those of technique. Whilst some sketches may reveal a slow and deliberate building up, or others a swift freely-executed approach, they all share the same common factor that they were produced over a period of time. It is this dimension of time which supports, perhaps even provokes.
changes in objectives and intentions during the process of sketch (or drawing) construction. It is inevitable, given the feedback mechanisms of the human mind, that one action should influence the next. Wirth’s identification of action and reaction, ‘the last drawn lines giving the idea for the following ones’ (Wirth 1976 p10) highlights the developmental nature of sketching.

The cognitive acts involved in the creative development of ideas are still poorly understood but there is evidence to suggest that the activity of sketching has an important role to play in the processes of creativity. The relationship between sketching and seeing has already been discussed. It was proposed that sketching not only facilitates a recording or reporting of the maker’s perception but that it was also intrinsically bound up with qualitative concerns of the perception itself. That is to say, sketching may be viewed as having a direct relationship with both a quality of seeing and a process of ‘selecting’. Bruce Archer noted recently that:

All acts of drawing, and especially all acts of sketch drawing, entail a great deal of selection of features for inclusion and features for omission, and of features for direct representation or features for transmutation. All of this is achieved through rapid and sustained mental cycling between external reality (or imagined reality), cognitive model and external representation. (Archer 1997 p40)

It is the capacity of sketching to act as both catalyst and facilitator for responding and selecting that the next sub-section dwells upon. It does this with reference to published studies within, and outside of, the fields of Design and Art.

2.2 Analogy and the Creative Process

Rawson provides some illumination of the human mechanism of response. He argues that the process of experience, from the most commonplace everyday coping with life to the remotest conceptual reasoning, works through analogy. Rawson presents human consciousness as a ‘continuous activity of scanning and matching’ that which we have seen (Rawson 1979 p18). He argues that during our lives we acquire a huge fund of remembered forms: visual, tactile, auditory and so on, and with them our mind ‘matches’ experiences as they occur. Rawson’s identification of an analogy process provides a useful bridging concept for understanding the role of sketching in creativity but there is little expansion on the role of sketching as a tool for conceptual development. The focus of Rawson’s thesis is that the objective of such a scanning and matching process is the establishment of relationships between new pieces of knowledge and stored information in the mind. The analogy process, he argues, allows us to recognise and identify phenomena by matching them dynamically with others that we remember and know. However, the advantages of deliberately
developing and exploiting an analogy strategy reside in the necessity for the mind to make sense of information when no obvious match can be found. That is, forcing the mind to make creative leaps. Matches are never perfect and this should not be expected since the objective is to establish links which may move away from the obvious pairings which are anathema to creativity. The creative mind needs to have the capacity to be free, to exploit analogy in order to present itself with new or unexpected relationships between phenomena.

Rawson presents the analogy process as a means of ordering and understanding but creativity demands that one also encourages a simultaneous process which exploits deliberate ambiguity. Interestingly, the analogy process can be just as successful for the latter as the former. In sketching it need not be the holistic concept which evokes analogy. Elements of a sketch may be viewed out of context and these may give rise to new directions in thought. Even the smallest units of a sketch - the marks and lines which result from each graphic act - are capable of conveying more than they were intended to portray. Thus sketches can provide a rich medium for evoking analogy.

Great works of drawing can assist interpretation and analysis. This may be because additional information is available in the form of knowledge of the artist or other works exists for comparison. The descriptive use of line by Leonardo DaVinci may, through analogy, suggest to us experiences derived from, for example, actual moving water and may even evoke recognition of similar lines used in other works of art. Similarly the caricatures of cartoonist Ralph Steadman evoke attitudes and feelings because of the analogies he makes accessible to our conscious and subconscious minds. However, it is through the workaday and commonplace sketches of those active in the creative professions that the scale of the exploitation of these qualities of drawing can be widely appreciated.

The creative interpretation and manipulation of information is not an easy process to define. Betty Edwards uses the analogy of the treasure hunt in describing her search for an understanding of creativity, including the uncovering of incomplete pieces of information and apparently contradictory evidence. Her work may not be the most academically rigorous of research studies but her outline of the creative process is worth noting here:

The creative individual, whose mind is stored with impressions, is caught up with an idea or a problem that defies solution despite prolonged study. A period of uneasiness or distress often ensues. Suddenly, without conscious volition, the mind is focused and a moment of insight occurs, often reported to be a profoundly moving experience. The individual is subsequently thrown into a period of concentrated thought (or work) during which the insight is fixed into
This Archimedean and somewhat romantic overview of the creative process considerably understates the role of creative problem definition but it does seem to offer some similarities with the notion of the mind actively seeking to construe sense by establishing relationships. At the time that Edwards published this the drawing research community was moving away from anecdotal evidence and one sees an attempt to align research work with emerging knowledge from the sciences, particularly the fields of psychology and neurophysiology. Even the title of Edwards' own best selling publication Drawing on the Right Side of the Brain (1982) highlights this alignment. The traffic flow in the opposite direction - that is, the interest by the science community in the creative process - had been well established by this time. In fact, by the early 1960s empirical research studies into creativity were well established and while the output varied in quality they certainly challenged widely held beliefs. American psychologist Jack Getzels grafted a problem-finding or problem-formulating phase onto the basic nineteenth century conception of the creative process as 'saturation, incubation, illumination and verification'. In presenting his 'formulating' phase as occurring prior to the accepted stages, Getzels provided a helpful insight into the creative process. He pointed out that creative behaviour does not consist of just solving problems of the kind which already exist or that continually arise in day to day life. Creative behaviour often involves a process of actively searching out and discovering problems that no one else has perceived. This point appears to be borne out by Albert Einstein and published in 1938:

The formulation of a problem is often more essential than its solution, which may be merely a matter of mathematical or experimental skill. To raise new questions, new possibilities, to regard all questions from a new angle, requires creative imagination and makes real advances in science. (Einstein 1938, quoted in Judson 1980)

There are many similar acknowledgements to the value of a question-asking strategy from a number of fields and yet there exists little research on the development of this capacity. If the incorporation of a question-asking strategy is so important to creative activity why is so little hard evidence available? One may add further questions such as 'what hindered the understanding of creative information processing within the brain' and, to return to the focus of this section, what might be the relationship of sketching to such creative manipulation? To explore these questions it is necessary to turn to a formative period in the field of psychology.

Section 1 Chapter 2 Perspectives on How Sketching Works
2.3 Towards an Understanding of Cognitive Processing

It was during the late 1950s and early 1960s that the psychologist Roger Sperry first described his research into the nature of information processing in the brain. His important theories proposed that there were distinct differences between the nature of information processing within the left and right hemispheres of the brain. Sperry proposed that while both hemispheres are involved in high-level cognitive functioning each brain half has its own characteristics and specialises in its own style of thinking. This dual-processing model proved very attractive to researchers in the subjects of creativity and design in the 1970s and drawing in the 1980s. There has been much published work aiming to support this thesis of preferred processing modes of each hemisphere of the brain and there is strong evidence to suggest that there are important tendencies. However, the notion of dual-processing perhaps over-simplifies the situation. Edwards, in her popularist publications *Drawing on the Artist Within* and *Drawing on the Right Side of the Brain* presents a polarised perception of a left hemisphere of the brain specialising in verbal, logical and analytical thinking via symbolic abstraction and a right hemisphere specialising in non-verbal, non-linear and non-sequential thinking. This is, perhaps, understandable given her objective to promote development of certain capabilities which she identifies as suppressed in a left-brain dominated society but one must approach the notion with caution. What is clear is that some experimental subjects display a preference for assimilating and processing information in whole or complete blocks while others prefer to break information down into discrete units. Edwards argues that it is the former which has become impoverished in our Western culture and that we need to redevelop this latent cognitive skill. It would appear to have important implications for this PhD thesis because sketches, with their pictorial abstraction, may perhaps require a developed capacity with those processing modes referred to by Edwards and earlier researchers as right brain activities. If one observes the generation of sketches by skilled practitioners one gets a sense of the pattern-seeking, non-sequential thinking referred to by Edwards but woven into it are strands of analytical and sequential thinking which manifest themselves in various ways. Perhaps the most revealing studies are those that explore the phenomenon of ambiguity in dual processing. Left mode thinking, it is proposed, rejects ambiguity and paradox whilst right-mode thinking embraces it.

The notion of simultaneous processing emerged in the 1970s and offers a more plausible model of human cognitive functioning in which, if there are two distinct modes of thinking, then they operate in a closely interrelated manner. Geschwind reflects the mood of the research community of the time when he states:

The specialisations of the isolated hemispheres should not be overstated. The right half of the brain does have some rudimentary linguistic ability. Moreover,
there are doubtless many tasks where the two hemispheres ordinarily act in concert. (Geschwind 1979)

Nevertheless, there would appear to be an imbalance in use of these modes, perhaps reflecting the cultural preference for the development of high-level thinking skills primarily through the exploitation of natural language and mathematical notation. With such a cultural dependence on symbolic abstraction, linear progression and logical thought, it is understandable that the opacity of ‘visual’ processing may be deemed to be less important or relevant to contemporary society.

Chapters Three and Four examine the phenomenon of design and designing but there is merit in first bringing together the strands of drawing, sketching and cognition research and placing them within the context of ‘design thinking’ and ‘visual thinking’.

2.4 Visual Thinking

In his analysis of the process, Michael Tovey (1984) proposes that ‘design thinking’, an ill defined but recurring theme of the time, and simultaneous processing share many similarities since they both operate with interactive cognitive styles. He goes on to link the contemporary understanding of cognitive processing with what he terms ‘visual thinking’. He defines this as a right-brain phenomenon of synthetic-holistic functioning and cites McKim (1950) in support of the value of ‘thinking visually’ in problem solving activity. He presents analyses of research studies undertaken with transport design students in higher education where visual thinking skills are held to be more relevant than analytical, codifying techniques characteristic of left mode thought. Importantly, he notes how readily the student subjects refer to sketching to augment their thinking. This may not be surprising if, as one might suspect, they were present in that design institution as a direct result of their proven abilities with drawing and visual thinking.

The concept of visual thinking is not new. Bruce Archer had identified a capacity for ‘imaging’ in the early 1960s and had highlighted the neglect of its development in education. McKim had developed this by discussing how visual thinking is greatly facilitated by procedures such as sketching in a three way interaction of seeing, imagining and drawing.

The nature of visual thinking, and perhaps more importantly that of sketching, within such a cognitive processing theory is still the subject of speculation. It is generally accepted that cognitive processing involves such a complex integration of function and location that definitions referring simply to right hemisphere and left hemisphere activity are outdated. Tovey (1986) sums up the uncertainty regarding human cerebral
asymmetry with reference to numerous contemporary journals of science. Importantly he notes that aspects of visuo-spatial thinking - particularly mental image creation - should not be viewed as exclusively right hemisphere activity. He concludes:

What seems likely is that in visual thinking the two halves of the brain may approach similar tasks but employ different processing modes: the right employing a simultaneous-synthetic strategy and the left a serial-analytic strategy. Thus a more complete understanding arises from the matching of initially separate simultaneous mental operations. (Tovey 1986)

Tovey’s conclusion begins to reveal a contemporary sympathy for the widespread advantages of developing and employing a visual thinking capacity. Whilst it has value in everyday situations it is essential to design activity.

It may be possible to discern a certain maturity to the drawing research community by the mid 1980s. Academics such as Tovey had drawing research published in leading journals such as Design Studies. Also, many universities were establishing new and innovative research groups comprising members from both the arts and science communities. One reason for this was the opportunities afforded for research in the rapidly expanding area of human computer interaction. Technological advances and user preferences offered opportunities for such interaction to increasingly utilise graphic imagery. Drawing research received a tremendous shot in the arm as a result of the commercial opportunities to improve the productivity of people interacting with and via computers. However, while a myriad of sophisticated graphics packages were developed - some providing photo-realistic images of three dimensional objects and others offering a seamless interface with engineering and manufacture - the support of humble sketching activity, exploited in numerous professions, was neglected. The knowledge of exactly how sketching worked was not available to the commercial players. Even less was known about the functioning of drawing and sketching in the dynamic activity of design which was itself experiencing rapid change. The final part of Chapter Two concerns recent research into how sketching works. Nearly all the sources quoted in this sub-section published their findings after the two projects presented in this document. However, this disruption to the chronological order of the research is intended to allow the reader to perceive the significance of the author’s own work and to appreciate its context and contribution to knowledge.

2.5 Recent Research into How Sketching Works

The beginning of this Chapter referred to Jonathan Fish who recently proposed that deliberate indeterminacy or vagueness in sketches brings into play a basic capability of the human brain to make sense of incomplete information. This mechanism, Fish
proposed, has its roots in a survival mechanism for making sense of incomplete information in potentially threatening situations. His thesis goes on to propose that any system of drawing which inhibits the incorporation of indeterminacy may be detrimental to certain types of creative activity such as design. Clearly there is a relationship here with earlier notions of the positive qualities of ambiguity, but Fish goes further by attempting a comprehensive analysis of the wider phenomenon of indeterminacy, of which ambiguity is only part. It is the nature of the relationship between indeterminacy and design thinking which is of interest here.

In a paper by Fish and Scrivener (1990), a broad distinction between information types is identified. On the one hand exists descriptive and propositional information - often characterised as a symbolic or verbally-focused system. And on the other exists depictive information which attempts to directly represent aspects of a given phenomenon. While their definitions for each are necessarily broad (since they have to encompass various applications and various levels of abstraction) the authors propose that sketches have the important function of assisting the mind to translate descriptive propositional information into depiction. This depictive information, it is proposed, is then available for other cognitive processes of interpretation which may lead to new and perhaps original descriptive information. Furthermore it is proposed that depictive processing may have a significant inter-relationship with propositional processing thus lending support to the identification of an integrated processing capacity of the mind.

This work was developed by Fish during subsequent years with a focus on cognitive processing and the mechanism of an exploitation of the proposed indeterminacies of freehand sketching in creative activity such as design. Fish builds upon certain 'types' of indeterminacy and proposes that these types of indeterminacy, currently seen in the creative professions, extend back at least as far as the Renaissance. He proposes, via an analysis of research drawn largely from the cognitive science community, that sketches function for the following five reasons:

i. Sketches are intermediate representational types which facilitate the mental translation between descriptive and depictive modes of representing visual thought.

ii. Sketch attributes exploit automatic processes of perceptual retrieval and object recognition to improve the availability of tacit knowledge for visual invention.

iii. Sketches are percept-image hybrids. (that is, they owe something to the drawer, the viewer and the thing being depicted). The incomplete physical attributes of sketches elicit and stabilise a stream of super-imposed mental images which amplify inventive thought.
iv. By segregating and isolating meaningful components of visual experience, sketches may assist the user to attend selectively to a limited part of a visual task, freeing otherwise overloaded cognitive resources for visual thought.

v. Sequences of sketches and sketching acts support the short term episodic memory for cognitive actions. This assists creativity, providing voluntary control over highly practised mental processes which can otherwise become stereotyped. (Fish 1996)

It remains to be seen whether the findings deriving from studies involving the particular requirements of industrial design, with its need to address functional and technical matters inherent in products for our culture of mass production and mass consumption, have any obvious parallels with the observations of Fish who was concerned with an inquiry into sketching within the fields of painting and drawing as much as the design of artefacts.

Vinod Goel has also been concerned with the value of indeterminacy in sketching for designers. In Sketches of Thought (1995) he echoes recent authors such as Fish and Scrivener in promoting important functions for drawing beyond mere externalisation of developed concepts. He involves himself in the depictive-descriptive debate, offering a symbol system as a common denominator in a continuum between depictive (picture-like) and descriptive (language-like) representations. Sketching is presented as significant in the 'problem-solving' phase of design for its ability to support translation and transformational processes. As noted earlier, some researchers may dispute the existence of any such 'phase' of problem-solving but there is growing evidence to support the notion that sketching can assist cognitive processes concerning problem formulation and the related organisation and transformation of information. Goel summarises his experimental predictions for how sketches support problem-solving, thus:

i. The dense ordering of symbols in the system of sketching provides a degree of fine-grainedness by making every distinction count as a different symbol. This reduction in distance between symbols helps insure that possibilities are not excluded and helps to transform one symbol into another.

ii. Ambiguity of the symbol system of sketching insures that the contents of symbols during the early phases of design are indeterminate. Ambiguity is important because one does not want to crystallise ideas too early and freeze design development.

iii. The dense ordering of reference or content classes in the symbol system of
sketching insures that possibilities are not excluded and helps to transform one idea into another.

(Goel 1995 p193)

Goel has adopted an experimental approach to his research which is directed by hypotheses concerning the functions of sketching within design activity. This contrasts with Fish's philosophical analysis of the experimental and philosophical studies of other researchers. Interestingly, Goel exploits computer based design activity in his experiments (albeit with individuals and with relatively basic software) which potentially increases its relevance to the aims of this thesis. Both Fish and Goel are critical of the limitations imposed by computer based working. Sketching using traditional media such as pens and pencils on paper is presented as rich in evidence of two types of transformation of information - lateral transformations involving progression from one idea to a different, but related, idea; and vertical transformation where progression involves drawings which are a more detailed version of a previous drawing. Limitations to our understanding of drawing and particularly sketching have given rise to computer systems which fix and stifle that cognitive capacity they intend to support. Goel is able to present quotes from his research subjects to highlight this situation: "It (MacDraw) is very frustrating ...unless you have an idea of what you want before you even sit down" (in Goel 1995 p201). Currently the general impression discerned from the drawing research community would appear to be that traditional techniques of sketching are superior to computer based resources for design sketching because they are better at supporting complex cognitive processes concerned with imagining future objects. Clearly there are relative advantages and disadvantages to both traditional and computer based media such as portability, convenience, transferability, storage etc but it would seem that computer based sketching has some way to go yet before it provides the qualities that are required by users.

Sketching via traditional media has been recognised as a sophisticated tool for accessing stored information. Fish refers to the role of sketching in 'recognition mechanisms' which provide a means for an individual to access their unconscious visual memory. If, as cognitive science now suggests, certain types of information exists in the brain in non-verbal forms then access to and manipulation of this information is likely to require a mechanism which can operate across a cognitive spectrum. Furthermore, sketching appears to be very suitable for exploiting indeterminacy via, for example, visual ambiguity. Sketching supports open-ended, creative and generative strategies which can be used to multiply ideas. It also supports strategies concerning translation between, for example, descriptive and depictive visual information. This capacity has been appreciated by those involved in visually creative subjects, notably the arts, since the time of Leonardo DaVinci and more recently by those responsible for a wide range of design activities. It seems likely that strategies of information analysis and creative
generation operate symbiotically within design, and sketching would appear to be a very appropriate support tool. Sensory information, for example from the eyes, and retrieved information from memory are integrated via sketching so as to construct images representative of future conditions.

Recent research has further illuminated the importance of drawing within designing. Verstijnen (1997), for example, has conducted experimental studies which seem to reveal a greater importance of sketching in analytical procedures of design (three-dimensional design tasks and visual organisation tasks) when compared to synthetical procedures in the same design tasks. Given that design activity as represented by the design professions possibly has a closer integration of these two procedures (explored in Chapter Three) than Verstijnen has allowed, the important feature emerging here is the role of sketching in a combined analytic-synthetic strategy. Indeed, the more holistic or integrated models of sketch functioning may be the only ones to accurately represent design activity. Fish even goes so far as to suggest a meta-functioning via his fifth hypothesis which proposes that sketches, and the act of sketching, supports visually the users’ conscious awareness of their own thought processes.

These perceptions of drawing have important implications for research strategies. It is not at all clear that closely controlled, laboratory studies such as those by Goel or Verstijnen are any more appropriate for determining knowledge about the phenomenon of drawing than observational studies or, for that matter, philosophical monographs such as that by Fish. It is clear that drawing research relies upon knowledge from other fields in the sciences and the arts and its methodology may need to be deliberately broad as the drawing research community seeks to establish some form of maturity. The issue of appropriate methodology is returned to in Chapter Five which examines different possible approaches.

The next chapter explores the second of the three perspectives, the location of drawing and sketching within a wider language of modelling in design activity. It discusses why drawing and sketching might be particularly useful for the types of activity required of designers.
Chapter Three

Drawing and Sketching as Modelling in Design

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3.1 The Emergence of the Importance of Solution Conjecture in Design Methodology

In response to a growing interest in studies of design methodology during the 1950s a number of papers emerged - largely as a result of conferences by a small but active design research community. Particularly worthy of note was a growing recognition of the need for a formalisation in the field of design research and an acknowledgement that methods and procedures of design activity could valuably be analysed. Characteristic of the period is the fragmentation of research activity leading to localised and isolated theories pertaining to particular professions such as architecture and mechanical engineering. At the same time there does appear to have been a certain marginalising of research activity relating to those professions which lay towards the art and craft end of the design spectrum. Up until the early 1980s the existence of the binary divide in Higher Education had a clear influence with engineering and architecture existing largely in the university sector with its culture of academic research while art and design subjects were mostly located in non-university institutions whose research culture and procedures inspired different outputs - more often associated with professional practice. Industrial design was an anomaly. While it clearly shared some aspects of a technological and methodological knowledge-base with engineering it was taught, almost exclusively, alongside art and design subjects in the Polytechnic sector.

In 1954 Nigel Cross published an edited selection of papers which allowed the design research community to reflect on the developments it had experienced over the past two decades. Titled *Developments in Design Methodology* it represented influential articles of the 1960s, 1970s and early 1980s charting the state of knowledge regarding the methods and procedures of design activity. In what has been termed 'first generation' thought, researchers such as Archer and Jones proposed that the design process comprised of logical analysis and creative thinking (Archer 1963). Such a belief gained widespread acceptance, particularly as it appeared to correspond with the emerging theories of cognitive processing discussed in Chapter Two. However, a certain scepticism in the research community of the time is evident. Many of these researchers were practising designers and they failed to see the reported divisions in their own cognitive process. In particular, they rejected the notion of design as simply an explicit and objective process of problem definition followed by a creative phase. First generation thought appeared to subsequent researchers as a relegation of complex design skills to either systematic finding-out or an impenetrable and intuitive process of concocting solutions. Studies undertaken into the nature of real-life design problems, notably by Rittel and Webber (1973) but also by many others, encouraged alternative theories regarding design methods.

Significantly, Roozenburg and Cross (1991) in their reflection of this early period
identify a 'consensus' model within the engineering design process which, they propose, displayed a certain desire for unity within established fields whilst excluding those fields - notably industrial design - whose methods did not fit the paradigm.

As applied to engineering design, the consensus model of the design process outlines a sequence of 'activities' which in turn lead to intermediate results such as specifications or proposals. The activities are grouped into four phases:

- clarification of the task
- conceptual design
- embodiment design
- detail design

Such a model is based on the systems engineering approach to the development of large or complex technological and socio-economic systems. As such it seeks to define functional behaviour as physical principles governed by physical laws. Essentially it is a problem-focused strategy aimed at specifying and predicting behaviour and, theoretically, it operates in a linear manner. However, a breadth has been identified by Roozenburg and Cross with reference to a twin axis graphical model originally proposed in the 1960s:

*The vertical dimension corresponds to the origination phases in the lifecycle of a product (such as: feasibility study, preliminary design, detailed design, planning for production, planning for distribution, planning for retirement). The horizontal dimension is the problem-solving process that takes place in every phase of the vertical structure: analysing and defining problems, synthesising solutions, simulating/predicting performance and evaluating and choosing the best system.*

(Roozenburg & Cross 1991)

It is not at all certain to what extent the actual procedures of the engineering professions are represented by this generalised engineering model but it would appear that there has been a clear operational emphasis on the vertical dimension in the development of products. Furthermore, the model assumes that relevant strategies can and will be brought to bear at each phase of activity by participants. Perhaps, more importantly, it condones the misguided perception that each phase has its own particular strategy - that to mix techniques or to apply strategies out of 'accepted' contexts would be detrimental to the outcome.

Two more characteristics of the engineering model should be mentioned. Firstly, it is assumed that design should proceed from the general and abstract to the particular and concrete in order to keep the solution space as large as possible. Secondly, complex
problems should be split into sub-problems from which sub-solutions are to be found and synthesised into overall solutions for the design problem. The model is not without merit but it has limitations, particularly where the nature of the problem is ill-defined and does not lend itself to systematic analysis. It is for this reason that architects and industrial designers have pursued research into alternative models. Understandably, they are founded on the same research studies of the 1950s and 60s and exhibit similarities in terminology and philosophy with those defined by the engineering communities. The work of Jones has been influential here, but within a much smaller community.

A growing dissatisfaction with the assumptions of the engineering model by researchers in the 1970s (in architecture particularly) led to alternative models. Jane Darke’s seminal paper *The Primary Generator and the Design Process* (Darke 1979) and Brian Lawson’s book *How Designers Think* (Lawson, 1984) both offer sophisticated analyses and a sensitivity towards a more integrated model of design. What stands out, however, is the acknowledged importance of solution-led procedures in design activity. Both authors base their findings on close observation of individuals. Architecture, engineering and town planning are represented. They reveal a strategy which involves the development of ‘solution conjecture’ as a means of further comprehending the nature of the problem. Whilst the strategy appears to share both the logical analysis and creative thinking of first generation understanding, it is the articulation of the nature of a process of solution conjecture that has relevance for this thesis. Hillier et al (1984) questions the orthodox view (at the time) that designers should resist bringing their own preconceptions to bear on the problem. Instead they argue that: ‘We cannot escape from the fact that designers must, and do, prestructure their problems in order to solve them’. Importantly, Hillier, along with other researchers of the time, identify a naivety in the prevailing analysis-synthesis model. Contemporary studies in the field of architecture identify limitations to a model of designing whereby exhaustive problem analysis must precede solution synthesis. It was proposed by some that this model was the antithesis of real architectural practice where experience and the ability to predict were more important. Investigations such as these shifted the balance of design research but a polarisation of views, rather than a new consensus, resulted.

The division has many roots; an increasingly fragmented design community with each faction seeking to stamp its own mark on a shared methodology; an increasing volume of design research by a new community of academics and practitioners drawn from the applied arts joined the established forum of researchers from architecture and engineering-related fields; perhaps also the growing popularity of philosophers such as Karl Popper with a liberal and participatory model of theory construction. Central to this division are views concerning the perceived function and importance of conjecture.
In Hillier's model of design a designer progresses via an iterative process of solution conjecture, analysis and evaluation. This model failed to attract support from communities such as engineering where, traditionally, problems were closely defined and specified. However, in architecture and in subjects such as industrial design an emphasis on human and other less tangible factors of the problem field as well as the apparent re-establishment of faith in the experience of the designer resulted in significant support for the conjecture-analysis model of design. Whether one agrees with the significance of conjecture or not it is clear that the activities of design professions such as industrial design and architecture require procedures and tools to support the creative and analytical activities described by Hillier, Darke and Lawson. The next sub-section presents and explores modelling as a necessary and appropriate procedure for some of these branches of design.

3.2 Modelling as the 'Language' of Design

In his examination of the creative strategies of a variety of scientists and technologists, Horace Judson refers to Man's desire to make 'models' as an 'instinctual and profound human response to comprehending the world' (Judson 1980 p114). His definition of the term 'model' would appear to encompass many types of output. He suggests that modelling is undertaken by various people and professions and at all ages. Children make models of the physical world they know whether this be with building blocks, sand or manufactured toys. They also model the social world around them, as they perceive it, through dolls and role play. At the other end of the age scale intricate models of such things as sailing ships and locomotives, constructed by those in retirement, can amaze onlookers with their detail and accuracy. The interesting paradox in both cases, as observed by Judson, is that both groups undertake their modelling with seriousness and with a sense of fun. Scientists, technologists and designers exhibit this same paradox in that modelling can be undertaken with a formal and deliberate seriousness and yet they will often refer to their modelling as 'playing' with an idea.

Definitions of modelling are difficult to pin down because of the variety of manifestations of models and the functions to which modelling activity can be applied. The Open University established a useful foundation in this area through the courses T262 and T263 on Design and Innovation (Walker 1983). More recently modelling has been discussed by Ken Baynes:

The term 'model' is used by scientists, mathematicians, technologists and designers to mean something which stands for something else. In general, models are powerful because they isolate an aspect of reality and allow us to represent, interpret, manipulate or control it. Models have predictive power.
because, to use computing language, they can be 'run' to simulate what will happen if proposed changes are carried out. They are indispensable for design activity because they allow designers to develop their designs and understand their likely effect before they are put into practice. (Baynes 1992 p13)

Baynes goes on to identify three categories of two dimensional and three dimensional models which he terms Iconic (looking like a selected aspect of existing or proposed reality): Symbolic (models using an abstract code to stand for an aspect of existing or proposed reality such as mathematical models) and Analogue (models using diagrams that stand in for, but do not look like, an aspect of existing or proposed reality such as critical path analyses).

Modelling has an important dual role in problem-centred and solution-centred strategies. For the scientist, certain modelling strategies assist in the creation of the theory while other modelling strategies allow it to be tested. Similarly in design there is a need to employ creative and evaluative modelling strategies that both illuminate the 'problem' and assist the generation of an appropriate 'resolution'. In order to develop this line of thought it is necessary to identify an important misconception about the nature of designing which was explored recently in a publication by Garner and Evans (1997 p114).

3.2.1 Solving and Resolving Design Problems

Some early publications in the field refer to designing as a 'problem-solving' activity (see for example Green 1974). This may be viewed as an inaccurate term because very rarely can a definitive answer to a design problem be provided. Design problems do not lend themselves to being 'solved'. Designing is a process of compromise involving conflicting factors and the best a designer or design team can hope for is to 'resolve' the conflict using the optimal mix of the conflicting factors. For example, many products could be safer if the consumer were willing to pay more for the necessary research or development; lower unit costs may be achieved if manufacturers did not stipulate that existing machinery should be used; new technology may improve a product if only a competitor would provide it! All the factors are to a greater or lesser extent in a state of flux and they are resolved via a process of negotiation and optimisation. This is where modelling is so vital to the product design process. Modelling is a means of working with conflicting requirements. It can be used to bring certain desired features to the fore so as to examine, evaluate and communicate a particular 'mix' but, equally importantly, modelling is, in part, the deliberate and planned strategy by which ideas can be juxtaposed and manipulated. Relationships can be posed, as Darke has suggested, as conjecture for possible resolutions and, more excitingly, unexpected but potentially positive relationships can be engineered in a deliberately unfocused strategy.
Modelling is the vital tool for a 'what if' strategy - as in 'what if I bring these two or more features together' - and is vital to innovation. Even if a design brief could be solved it is unlikely to be solved at the first attempt. It is more likely that modelling would assist this process.

3.2.2 An Integrated Strategy for the Generation and Interpretation of Ideas

Bruce Archer developed the notion of modelling to include 'cognitive modelling'. He provides a useful definition and clarification of terminology:

The expression 'cognitive modelling' is intended to refer to the basic process by which the human mind construes sense experience to build a coherent conception of external reality and constructs further conceptions of memory and imagination. The expression 'imaging' is intended to refer to that part of cognitive modelling which construes sense data and constructs representations spatially and presentationally, rather than discursively and sequentially. (Archer 1992a p6)

It may be relevant to consider a radical proposal that the development of cognitive modelling skills is the primary aim of design education - all other modelling strategies being taught so as to inform and develop the capacity to model in the mind - insofar as designing cannot occur without the ability for cognitive modelling.

Modelling has a vital role in the creation, development and evaluation of ideas for individuals and for groups. The ambiguity inherent in some modelling types can encourage various perceptions of information and this assists creative development. While the process of interpretation may be based on a primitive human survival mechanism as suggested by Fish the construction and deliberate exploitation of models displays a much higher order of intelligence in the generation of ideas. A strategy of deliberate ambiguity in information can be effective on a personal basis - allowing an individual to exploit the cognitive capacity for creative interpretation - and it can assist groupwork by encouraging discussion of differing interpretations and the quality of the model.

Physical models, including sketches, do not necessarily communicate the hoped for, intended or required information. Furthermore, many of the failures of teamwork may, perhaps, be attributed to the absence of shared conceptions. One of the issues for design education must be to develop the capability to apply, understand and collaborate using relevant models and modelling techniques so as to bring about a joint understanding which appear to be an important requirement for successful teamwork in design. Section 5 returns to the issue of shared models.
3.3 Towards an Appropriate Means of Modelling Design

Conjectures

Within industrial design an iconic model can refer to many things including a sketch or a computer based rendering (both two dimensional models) and a test rig, simulation or breadboard electronic circuit (three dimensional models). However, the term is often mistakenly limited to three dimensional representations of form. This is perhaps understandable since we see so many models of this type. Scale models such as an architect's proposal for a new housing scheme or a child's model car are common and are helpful models since we may walk around, enjoy, examine, test and generally evaluate certain qualities - particularly visual qualities. Many design schemes will not get the go ahead until full-site models have been seen and agreed - the Channel Tunnel train of the early 1990s being a good case in point. However, modelling takes many forms and in reality distinctions between types of physical models may not be so easy to make. Various professions, including the design professions, exploit models which may be seen to exhibit qualities of two or more of the types identified by Baynes above. Such hybrid models are constructed as a result of particular requirements of a defined task. There are also intimate relationships between non-physical, cognitive models, as discussed by Archer, and other, tangible models.

Modelling is a means of formalising our understanding, thereby facilitating examination, evaluation and communication. Each type of modelling entails a simplification of information - indeed the value of many models lies in their selectivity and reduction of information. Nevertheless, such a process of simplification gives rise to limitations which are important to acknowledge. Using models which emulate reality only in certain respects must have limitations in, for example, examining phenomena, evaluating proposals or communicating concepts. The very ambiguity of a model may be both an advantage and a disadvantage. Hence designing, in many different subject areas, requires a familiarity with various modelling techniques for the communication, evaluation, and generation of ideas.

It was noted above that by the late 1970s there was significant criticism of the notion that all types of design activity must begin with an exhaustive problem specification from which solution concepts can be synthesised. Jane Darke and her notion of a 'primary generator' (Darke 1979) - a concept which is imposed or identified in order to guide progression - struck a chord with the design community of the time (including some engineers) and particularly in architecture from which her subjects were drawn. Darke's model may be summed up as a generator-conjecture-analysis model in which proto-solutions or pre-structures were accepted and encouraged so as to provide tangible output for evaluation and stimulation. Thus, the notion of modelling, which up until then had been viewed by the dominant engineering professions as a limited...
device for communication and testing, attained a central position - particularly in research undertaken in the fields of architecture and industrial design. Modelling offered the means by which proto-solutions were generated, developed and evaluated.

While any modelling type may facilitate conjecture, some models are more appropriate than others in particular situations. Modelling facilitates conjecture by providing a loose tangibility to new and imperfectly formed thoughts in order that they can be externalised for examination. This can be achieved with a variety of media. Cardboard, plasticine and, more recently, rigid cellular foam facilitate not just the externalisation of possible solutions but encourage the contemplation of the nature of the problem. However, the role of drawing and sketching in this has, until recently, been largely overlooked. Drawing can be used to communicate developed ideas and to assist the cognitive processes of interpretative and generative thought. Norman McNally, one of the research subjects presented later in Section 3 noted some years ago that:

Drawing is a very economical way of modelling, it is the fastest and best way of having a quick idea - a visualisation - of what is in your head and thus leads naturally into solid modelling. (AS7)

The discussion regarding the appropriateness or otherwise of sketching as an important modelling tool for the support of conjecture is informed by recent research into the human creative process and particularly by the phenomenon of 'emergence'. The following sub-section reviews established knowledge regarding the mechanism of innovation. It picks up the subject matter of Chapter Two via an examination of new research from the cognitive sciences which illuminates the functions which drawing performs in design activity. Importantly, it highlights a relationship between the exploitation of drawing and the achievement of innovation.

3.4 Drawing, Sketching, Innovation and Emergence

3.4.1 The Mechanism of Innovation

While our technological society appears to value the human capability to innovate there is little consensus regarding the nature of the phenomenon or its results. Similarly with the phenomenon of creativity; many will argue its importance but research over many decades has failed to provide a readily acceptable definition. Both appear to be elusive and subject to the context in which they are brought into being. The Concise Oxford Dictionary (COD) refers to 'making changes' and 'novelties' in its definition of the verb 'innovate', both of which could be interpreted as devaluing the quality of the phenomenon. The COD offers more scope in its definition of 'creativity', referring to 'inventive and imaginative activities' as well as 'routine skill'. Earlier research into
creativity by behavioural psychologists in the late 1950s and 60s, focused, perhaps understandably, on personality traits of creative individuals. Little was established regarding the operational issues of creativity or the mechanism of creative thought.

In order for innovation to take place there are practical conditions which must prevail, for example, the relevant technology or underlying knowledge must exist (see the comparison with the term invention below). Given these, Judson (1980) points to curiosity and an inner compulsion as motivating forces in scientific discovery and this may have parallels in the operation of innovation:

You must feel in yourself an exploratory impulsion - an acute discomfort at incomprehension. This is the rage to know. The other side of the fun of science, as of art, is pain. A problem worth solving will surely require weeks and months of lack of progress, whipsawn between hope and the blackest sense of despair. (Judson 1980 p5)

Meikle (1980) proposes that this capacity has an even deeper foundation - one based on survival:

The ability to think around a subject or idea and to create new ones has enabled humans to find new ways of surviving and developing.

This notion is still applicable in our technologically advanced society. Research into the mechanisms of the mind is well represented in the literature but while logical, rational and analytical processes receive some consensus, the mechanism of innovative thought is more elusive. The role of prior knowledge and experience would appear to be important to the ability to step outside of methodical procedures. The work of Edward de Bono is well respected and he refers to a transformational process whereby new insight is derived from old information through a process of restructuring in, what he terms, a 'flash of insight' (Debono 1969 p177). Whilst experience may be valuable there is a necessity to remain flexible so that preconceptions and old ideas can be questioned and new information, arrangements and opportunities can be identified. It is this informed flexibility that is central to innovation and which requires a developed modelling capability to operate.

The classical model of the mechanism of discovery suggests that a period of incubation is required during which time information is subconsciously transformed and awaits some form of trigger for realisation. William Lipscomb, Nobel Prize winner for Physical Chemistry, provides a typical case. He describes immersing himself in a problem before going to bed, consciously putting the problem out of his mind and allowing the subconscious to seek apparently random connections (in Judson 1980 p6).
This classical process of saturation and incubation does not necessarily hold true for contemporary innovators. James Dyson, the designer of the Ballbarrow and, more recently, the astoundingly successful Cyclone vacuum cleaner prefers a hands-on approach, facilitating creative thought during practical, making activities. This is not a major stumbling block. If one views modelling as an 'enabling' device, then the differences between science and design or between classical and contemporary merely reflect different preferences for, and appropriateness of, various modelling strategies. Modelling facilitates 'feedback' essential to a system of innovation which is founded on actions and their practical consequences.

In 1986 a collection of short papers was published by the Open University for the course T362 Design and Innovation. Edited by Robin Roy and David Wield, this course reader offers a variety of perspectives on innovation, invention and design. In this, Kelly et al refer to technological innovation as a 'milestone' in the process leading from invention (the first idea, sketch or model for a new or improved device, product, process or system) to diffusion (of the resultant product, process or system through a population of potential users) (Kelly et al 1986 p26). There appears to be a consensus that innovation refers to the application - particularly the commercial exploitation, of a new process or product. Invention, on the other hand, is the process of discovering the principle which may lead to exploitation (see Pye 1986 p48). This is reinforced by a definition of innovation offered by the Organisation for Economic Co-operation and Development (OECD):

Technological innovation is the transformation of an idea into a new or improved saleable product or operational process in industry or commerce. (OECD 1981)

Innovation, then, may be distinguished from invention and marketing but it is widely held to refer to a wide range of activities including research, design, development, market research, testing, manufacturing, and engineering. There would also appear to be qualitative differences. Roy views invention and innovation as involving technical advances in the state-of-the-art of a particular field whereas design is viewed as a process of making variations on that state-of-the-art. (Roy 1986 p5)

It seems clear that in innovation, creativity and even discovery, preparation plays an important role. A certain 'readiness' appears to be a prerequisite for ideas to be conceived or even anticipated. Some would argue that 'chance' has been as important to innovation as it has been in scientific discovery but preparation is still vital with chance merely 'favouring the prepared mind'. In recent research by Akin (1990) the ease for anticipation and the integration of conception and development in design innovation is presented. He argues that 'the creative process is a whole in which the conception of the idea influences, and is influenced by, the anticipated development'.

Section 1 Chapter 3 Drawing and Sketching as Modelling in Design
Interestingly, he goes on to speculate that 'the cognitive tools used in the development of the creative entity are also responsible for the inspiration that initiates the creative process' (Akin 1990 p103). One of these cognitive tools would seem to be the ability to identify, comprehend, order and arrange concepts in an act of preparation. James Dyson, the designer of the 'Cyclone' vacuum cleaner observed:

The more you get involved and study something in depth the more creative ideas arise. You can’t create marketable innovations as an amateur. (in Roy 1993 p130)

Experience would appear to be a key factor in preparation. Given the poor general awareness, low inquisitiveness and limited teaching of the mechanisms of the mind then experiential learning may be the only way most people can develop the tools and skills of preparation. Design research could do much more to minimise designers dependence on such experiential learning by illuminating strategies for identifying, comprehending, ordering and arranging concepts. In particular, design research could better illuminate the mechanism by which conjecture, manifested via sketching, facilitates the type of creativity necessary for industrial design.

3.4.2 Emergence and the Role of Sketching

In the 1990s the phenomenon of 'emergence' has interested a number of researchers in the field of design and particularly computer based designing. Emergence concerns both visual representations and the process of their interpretation. Research into emergence is thus involved with tangible outputs (such as models in the form of graphic images) and it also concerns our understanding of the perceptual mechanism of the human mind - what Tapia has concisely described as 'object and viewer' (Tapia 1997). Some researchers such as Gero and Yan (1994) have been concerned with shape emergence and the development of appropriate representations. Others have focused on physiological mechanisms such as vision (see Liu 1994). While research into the phenomenon of emergence is relatively new it has a well established foundation and many researchers base their studies on widely accepted theories of perception such as those established by the Gestalt psychologists many decades ago.

Soufi & Edmonds have explored the relationship between emergence and creativity in design and they propose that:

Emergent shapes in design are not only the result of perception constructing a model of the world but also a consequence of transforming the world. This view of emergence is necessary if we are to account for certain emergent shapes that do not exist in the model of the world as represented by the original stimulus pattern.
Since this view of emergence has commonalities with accounts of creativity based on transformation of conceptual spaces, it supports the assertion that emergence is creative. (Soufi & Edmonds 1996 p153)

If, as Soufi & Edmonds propose, the interaction between data (such as drawings and sketches arising during design activity) and a perceptual mechanism has a transformational effect then the quality of the creativity must depend upon the quality of the perceptual mechanism and the quality of the data. If this is true then emergence as a phenomenon must be central to design education which seeks to develop, amongst other things, a creative perceptual mechanism and an ability to exploit appropriate data for given problems.

It may be that some types of drawings and sketches are just not suitable as data for a process of emergence to take place - no matter how good the perceptual mechanisms are of the individual or team undertaking the design activity. It would seem that drawings which contain ambiguity - such as those represented by design sketches - seem to offer the most appropriate form of graphic data for emergence to be brought into being. Other types of drawings, such as those following closely defined symbolic conventions, may be of lesser benefit to the cognitive manipulations necessary in a process of emergence.

The development of computer based designing may be seen to have given rise to certain forms of beguiling but rather rigid image types and this in turn has caused researchers such as Soufi & Edmonds to observe that 'current computer aided design (CAD) systems do not provide sufficient support to the early conceptual stages of design' (Soufi & Edmonds 1996 p151). There certainly seems to be a mismatch between current CAD systems and the support of emergence which is required at numerous stages in the industrial design process. It may be significant that where emergence is most (but not exclusively) needed in computer based design activity - that is, in the early stages of conceptual design - individuals and teams appear to still resort to paper based sketching. This is one issue which links the two projects described in this thesis and is returned to in the final chapter.

Rieman, working in the field of computer aided sketching, confirms the widely held belief within the research community that the computing equivalent to the 'back of the envelope' type sketches lack important levels of incompleteness and ambiguity. He identifies two differing editing paradigms as partly responsible for this: 'Object oriented draw programs allowing complete objects to be moved, resized and otherwise altered without affecting other objects' and 'pixel oriented paint programs allowing individual pixels to be erased after they have been drawn' (Rieman 1997). His own alternative, which he has called 'J-Sketch' is presented as helpful in facilitating
emergence. Whilst it is apparently easy to use, it has retained - as many similar tools have - a mouse as input device and thus should be viewed as some considerable distance for the traditional sketching it seeks to emulate. While other current computer based sketching systems which do incorporate a 'pen', exploiting either a pressure sensitive tablet or a freestanding whiteboard to digitise the input, may appear to be an improvement there is little research which documents the relative success of computer based sketching systems for supporting emergence. Research into, for example, the intrusiveness of computer based tools and environments still needs to be undertaken and an appropriate evaluative mechanism still has to be generated.

Sketching would appear to offer a very appropriate type of modelling resource for use in a strategy seeking to facilitate emergence but it is not the only modelling type one could use. Three dimensional sketch models can contain a level of ambiguity and may be very appropriate for facilitating emergent thought. Similarly CAD models need not offer the rigidity of proposal seen in many contemporary applications. A combination of two dimensional and three dimensional models might be more appropriate in some design disciplines such as industrial design. Most of the current research into emergence focuses on basic graphic imagery so as to inform the computer research community. Much new work needs to be undertaken into the functioning of, and relationship between, various model types if the design community (particularly the industrial product design community) is to develop and apply the findings so as support future working practices.

Drawing practice does not exist in a vacuum. As discussed in Chapter One the exploitation of sketching is influenced by culture and environment as well as by our knowledge of physiological and perceptual mechanisms. The next Chapter examines the significant developments experienced by the design professions - and particularly the industrial product design profession - as a means of highlighting the logic of the research direction presented in this thesis.
Chapter Four

The Changing Nature of Design Practice

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4.1 Introduction

This Chapter aims to highlight the emergence of a phenomenon which has been termed by the author 'computer supported design teamworking' (CSDT). It is shown to be the consequence of the maturing and integration of two existing phenomena, namely the dramatic increase in the exploitation of computer aided design (CAD) and the pressures (commercial and otherwise) on design practice to operate efficiently in a wide variety of collaborative situations. Chapter Four first examines the reasons why computer based working, and CAD particularly, gained such a significant foothold in the design professions when the technology was still unproven and relatively unsophisticated. Secondly it highlights the reasons underpinning the trend towards teamworking in various design professions but focusing on industrial design. It is proposed that research into computer supported design teamworking has emerged in centres around the world as a result of the inadequacies exhibited by current attempts to integrate these two phenomena. Computer aided industrial design (CAID), a logical extension of CAD, is shown to offer important improvements for the support of design activities but its interface with the requirements and procedures of teamworking is still undeveloped.

Research into teamwork and teamworking has been undertaken in a number of fields. This has been taken up vigorously by the computer science community and a subject known as computer supported collaborative (or co-operative) working (CSCW) emerged in the mid 1980s. In spite of the fact that design teams offer a very good context for research into CSCW there are few significant studies. One such study (the ROCOCO project), which involved the author, is described in Section 3. There are even fewer examples of quality research which confront the issue of integrating CAID and CSCW in an appropriate computer based design environment. Chapter Four returns to the theme of Chapter One by reviewing current thinking on sketching as a modelling device within CAID and CSCW. It proposes that sketching might have a significant role in a CSDT environment and thus it sets the scene for the subsequent presentations of the two research projects of this thesis.

4.2 The Rise of Computer Aided Industrial Design

The design professions have never been slow to recognise the significance of sociological change nor the potential of technological developments. The industrial design profession is relatively young whether one views it as a consequence of the 1920s marketing campaigns of the USA or an emergent phenomenon deeply rooted in the ideological melting pot which was Europe in the early twentieth century. In both instances innovation, challenge and foresight were hallmarks of the early industrial design profession. It should not be surprising to find therefore, that when computers became commercially available in the 1980s the industrial design profession should take
By the early 1980s, desktop publishing was radically altering the graphic design and publishing professions. Computerisation was well suited to the two dimensional nature of such professions but industrial designers required considerably more. The need for three dimensionality throughout the design and development process required that new computer based tools were supplemented with traditional modelling techniques. The computing power to record and manipulate data relating to three dimensions just did not exist on a commercial scale. Physical models (both scale and full-size) continued to be constructed in industrial design practice. It is interesting to note that one of the focused interviews presented in Section 3 (Royden Axe) highlights this particular period of integration of computer aided design (CAD) into what was then Austin Rover (now Rover Group). Axe, then Design Director of this major British motor manufacturer, refers to the construction of full-size three dimensional models of new car proposals from which digitised data was taken for input into computer systems. This coexistence and integration of traditional craft skills and new computer aided design practices characterises industrial design practice of the major players in the 1980s. The reasons for it partly concern the need to facilitate design conjecture via an appropriate support of cognitive processes which required three dimensional aids to assist three dimensional thinking.

Early computer based tools offered little more than sophisticated drafting capabilities. While the resulting files could be stored, retrieved, distributed and amended the majority of the design and development was conducted away from the computer terminal. The significance of the emergence of three dimensional CAD (3D CAD) in the late 1980s has been discussed by McCullagh (1996). Whilst highlighting the practical difficulties for industrial designers arising from complex interfaces intended for larger engineering-type applications, McCullagh presents the new 3D CAD tools as an exciting and innovative departure from the reliance on traditional media and practices. 3D CAD offered the potential of interactivity that even traditional models could not offer. Surface modelling programs replaced wireframe systems - the former allowing the construction of complex curvature and facilitating high quality rendering. These were subsequently supplanted by solid modelling systems which offered a large number of significant advantages for organisations who were willing and able to make the considerable investment in hardware, software and personnel.

Solid modelling systems presented a major development towards a digitally integrated design process. The next sub-section discusses the economic pressures on commercial organisations at this time. Computer aided industrial design (CAID), initially via such 3D CAD systems, seemed to be compatible with the changes which commercial pressures demanded. Sophisticated new product development required considerable

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involvement by many individuals. CAID, via 3D CAD offered a means by which engineering, production, management and marketing could access, extract and modify data. It facilitated, for example, finite element analysis, tolerance and interference checking, assessment of mould flow characteristics as well as judgment of overall form, colourways and finish. It was, therefore, a significant facilitator of simultaneous engineering.

For the industrial design community such CAID packages also appeared to challenge the accepted practices of conceptual design. Freehand sketching was no longer the only rapid means to support early exploratory thought. Packages such as Alias offered industrial designers the ability to sketch 3D forms quickly and effectively. Not only could these be developed to a photo-realistic stage very quickly (for self assessment and for transfer to others via the new telecommunications technology), they could also provide the foundation for alternative strategies leading to engineering development. However, not everyone was convinced by the potential of CAID to unseat its rivals in traditional modelling techniques. Sketching particularly was the focus of many articles in the late 1980s which sought to articulate and defend the unique qualities of freehand drawing for many designers.

As discussed by Warburton (1996), the vision of a fully digital and integrated design process was apparent by the early 1990s. Indeed, as industrial design consultancies have come under increasing pressure in the 1990s to deliver data which is compatible with clients' engineering and manufacturing facilities then investment by consultancies in not just one but several CAID systems seems inevitable. Furthermore, as new product development becomes more integrated, then industrial designers will need to be more familiar with the various processes involved - from material specification to rapid prototyping technology. It seems likely that one phenomenon which will increase above all others is communication - communication within and between design teams; communication with others involved in the development, testing or marketing process; communication with information sources for current and future projects and communication with clients, business colleagues and perhaps the public. The integration of CAID with the capacity for effective communication has only recently begun. While file sharing, electronic mail and even teleconferencing has been possible for some time with the various CAID and communicational tools can hardly be said to be 'seamless'. Unfortunately, in today's highly competitive marketplace, manufacturers of such systems have a vested interest in non-compatibility even where it is possible. The exploitation of CAID, then, is partly the result of ongoing technological development - it is partly a 'technology-push' phenomenon; it is also partly a phenomenon of its economic culture, that is, it is partly demand led. It is this latter aspect which the next sub-section explores in more detail.
4.3 Teamworking in the Design Professions

The pressures on modern business have been well documented. Throughout the 1980s and the 1990s almost any conference or journal in the field of business studies or industrial management will make reference to changes which have taken place and are taking place as a result of these pressures. The Design Council in the UK is one of many organisations publishing data on this changing climate for business (see, for example, Lawrence 1996). The intensity of global competition, the constant and accelerating developments in technology, new and emerging legislation, and the growing flood of information (not least via the Internet) are regarded as components of a normal operating environment for industry. Such pressures have had significant consequences for the operation of a wide range of industries. Companies have had to be more skilful with resources including the management of people. More industries have had to engage in product improvement, development and innovation when confronted by home and overseas competition and an increasingly knowledgeable market. This has required the exploitation of teams of people, not just in design, but also via marketing teams, production teams, service teams etc and it has made inter-teamworking an important management objective.

Modern product development requires the implementation of teamworking for a number of reasons. It is rare these days to find a case of an individual designer developing and marketing a new mass manufactured product. The range of expertise concerning materials selection, ergonomics, production and marketing is usually way beyond the competence of one individual. Development costs are prohibitively high and, even where funding can be secured, it would be a foolish individual who did not exploit the expertise of others to ensure that the product does not fail in the marketplace. Additionally, user safety legislation usually demand sophisticated testing and evaluation. In an earlier research project by the author, a leading consultant designer stated that clients demand to see experts (in this case ergonomists) brought into product development because of the validity they are perceived to add to proposals (Garner 1988 p65).

Teamwork, then, has become a subject of great commercial interest in recent years. For the reasons stated above, there is a high demand for efficient teamwork and during the 1990s the emergence of a research interest in teamwork and designing is observable. In recent research at the University of Salford, Rachel Cooper and James Powell set out to examine how companies use design teams. In their paper Enabling Creativity to Flourish in Design (Cooper & Powell 1997) given at the European Academy of Design Conference in Stockholm, they discuss the exploitation of, and problems with, inter-disciplinary teams. They identify two types of inter-disciplinarity: intra-organisational teams which are multi functional and comprise members from
within an organisation and *inter-organisational* teams which involve partnerships between organisations. However, there is some belief that the organisation and management of such teamworking has not been as effective as it could have been. Minneman & Leifer (1993) argue that research into designing via teams must acknowledge the social as well as the technical nature of modern design practice. They adopt a largely observational strategy in studies of teams of engineering designers and propose that design work 'emerges from interactions among individuals and groups as they establish, maintain and develop a shared understanding' (Minneman & Leifer 1993). It is the mechanism of, and tools for, achieving a shared understanding in design team working which is of interest here.

Recent research at the Open University suggests a consolidation of interest in the social mechanism of design teamworking. Cross & Clayburn Cross (1995) propose six aspects which need to be considered:

- the roles and relationships within the team
- the planning of the design process by the team and their actions relative to that plan
- the gathering and sharing of information
- the ways of analysing and understanding the design problem
- the ways of developing and adopting design concepts
- the mechanism of resolution and avoidance of conflicts

Focussing on design as a social activity results in a general orientation toward the communications in and around the design work. It was for this reason that the ROCOCO project described in Section 4 took great care to examine the nature of communication in an example of computer supported design teamwork. The research described by Cross & Clayburn Cross took place as part of the experimental studies of design practice initiated by Delft University in the Netherlands and known as the *Delft Protocol Workshops*. The Cross & Clayburn Cross studies involved three team members whereas the ROCOCO project used pairs of subjects for research into team designing.

It might be considered that the commercial advantages to team working were sufficiently significant to inspire its exploitation and to drive vigorous new initiatives in design research. But one vital factor has so far been omitted and this must be considered as the primary generator for research into design teamworking. This is the rapidly developing potential for computers to support teams of individual specialists who may be located some considerable distance apart. The commercial significance is immediately apparent - if companies and organisations can facilitate co-operation and collaboration without face-to-face meetings there may be significant savings in costs and resources and it may have implications for improvements in the quality of output,

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where management decisions or new product development. As introduced above, the 1980s saw the emergence of computer supported cooperative working (CSCW) and this is examined in detail presently. It has been a largely technology driven phenomenon and research studies have lagged behind the development and marketing of new computer-based tools. Never has research into teamworking been more desperately needed so that new tools can address the real needs of the user groups. Research into CSCW emerged in the early 1980s largely associated with the computer studies departments of major universities in the USA. The application of CSCW to design is less well established but more research is emerging during the 1990s. Particularly lacking is research into the requirements of CSCW environments which are intended to support the social and technical nature of group design. Almost non existent is research into how CSCW environments may support innovation and how they might encourage the 'shared understanding' within teams as described by Minneman & Leifer (1993).

4.4 The Roots of Computer Supported Design Teamworking

As in all young research domains the terminology used to identify particular aspects or activities develops and changes as the subject matures. Rejection and clarification characterise the search for names and for precise definitions. The term computer mediated communication (CMC) is a relatively new one emerging, as it does, from older studies into computer supported co-operative work (CSCW). According to Wilson (1990), Irene Greif (then at Massachusetts Institute of Technology) and Paul Cashman (of Digital Equipment Corporation) were the first to use the term Computer Supported Co-operative Work as the title for a workshop they organised in 1986. Apparently, they did not wish to give special emphasis to any of the individual words of the term. Rather, they were looking for a shorthand way of referring to a set of concerns about supporting multiple individuals working together via computer systems.

The 1980s witnessed dramatic technological changes which provided the essential footholds for the emergence of CSCW. The widespread availability of low cost personal computers brought computing to the masses and an erosion of perceived barriers between home and office work is evident. Owning a computer and being computer literate were, and to some extent remain, high status achievements in our culture. In the home, office, factory and shop, computing power was in the hands of the non-specialist computer user. Having established a widespread market confidence there emerged a move towards linking or 'networking' computers thereby allowing users access to a variety of services. Initially these were local networks limited to particular buildings or commercial enterprises. Developments in speed and capacity of such networks, primarily the introduction of Integrated Services Digital Networks (ISDN) and other telecommunication facilities have made access to remote information

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services practical. Improved computing power, more appropriate human interfaces, and the development of multimedia technology have had a huge effect on the acceptance of communicating with, and through, computers. The 1980s saw the establishment of the 'information age'. The commercial and social pressures for all types of information created an insatiable demand for improved tools of interaction and communication. It was from this hothouse of technological innovation and market demand that CSCW emerged.

The central concerns of CSCW were not new. They were drawn from the body of knowledge which emerged from earlier studies of group interaction and teamworking. What was new was the notion that computer technology could facilitate such group working by individuals who may be located considerable distances apart. Furthermore, emerging computer based services could be integrated into groupwork as never before offering possibilities for sophisticated commercial and leisure activities. Regarding this formative period Wilson observes:

It immediately became clear that the range of computer support that might be provided to work groups of all sizes was very great; and that, in view of the fact that organisations, by their very nature, rely on people working and co-operating together, CSCW's potential benefit could be huge. (Wilson 1990 p5)

However, the title did not suit all researchers. Some pointed out that any research involving 'co-operative' work would find itself tied up in the issues of identifying, establishing, maintaining or proving co-operation between participants. It was argued that 'collaboration' was a superior term since it was easier to demonstrate collaboration than co-operation. Thus for many research groups (including the ROCOCO project) CSCW came to stand for computer supported collaborative working.

The term 'Groupware' appears in the early literature associated with CSCW and is defined by Johansen as:

a generic term for specialised computer aids that are designed for the use of collaborative work groups. Typically, these groups are small project-orientated teams that have important tasks and deadlines. Groupware can involve software, hardware, services, and/or group process support. (Johansen 1988 p8)

In this definition the emphasis is on the design of computer aids, that is, on the enabling technology. Wilson suggests that:

CSCW is understood to be a generic term which combines the understanding of the way people work in groups with the enabling technologies of computer
networking and associated hardware, software, services and techniques.
(Wilson 1990 p5)

This definition emphasises the need to understand group work, but is neutral about its specific character. Bannon and Schmidt (1989) place more emphasis on the idea of understanding co-operative work when they assert that, 'CSCW should be conceived as an endeavour to understand the nature and characteristics of co-operative work with the objective of designing adequate computer-based technologies'. CSCW systems seem to conform better with Wilson's definition, since co-operation is usually assumed to be a property of the group behaviour the system is intended to support. To some extent this is a reflection of our lack of understanding of the nature of co-operative behaviour, and how to detect and measure it. However, some find the emphasis on co-operation too limiting, believing that effective group work often involves competition and conflict. Computer Supported Group Work might actually be a better title for Wilson's definition, and indeed a better term for describing the systems currently labelled CSCW. However, notwithstanding the lack of an agreed definition, a key characteristic of CSCW system research and development is the emphasis on understanding group work.

As noted above, CSCW is not subject specific. It is a generic term which might as easily apply to groups of teachers, sales representatives or oil company executives. It neither implies the type of people involved nor the type of work undertaken. It is thus too broad a term for use in this thesis. What is of interest here is a very particular context for CSCW, that is, the support (via computing and telecommunications technology) of collaborative working by groups of people engaged in design and design-related activities. As discussed above this context presents a formidable requirement to support creative, evaluative and communicational strategies of its participants not to mention the requirements for access to information beyond the immediate arena. If it is not unique in CSCW then computer support of product design teams must be very rare in the potential extent of its demands. Thus the term 'computer supported design teamworking' (CSDT) is preferred to CSCW since it more accurately describes the context of research described in Section 4 of this thesis. While Section 4 presents the ROCOCO project as clearly located in CSCW research the subsequent revisiting of the data via the Analysis of Graphic Acts (AGA) project (and on which most of the analysis is founded) is viewed as research into CSDT. The central concerns are the procedures and findings of a research project into sketching within CSDT. Section 3 presents very little analysis of computer supported working. Many of the focused interviews took place before networked computers had gained such a strong foothold in the profession and thus CSCW and CSDT were still only just emerging. However, the transcripts have much to offer an analysis of 'design teamworking' and in their own way provide an important contribution to the

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conclusions regarding computer supported design teamworking and its relationship with drawing and sketching.

While studies of the functions and value of drawing predate research into computer based designing by many hundreds of years the phenomenal growth of the latter has provided a significant stimulus to drawing research in recent decades. As has already been shown drawing research has embraced new knowledge emerging from very diverse fields such as psychology, neurophysiology and education. Current knowledge about drawing has emerged from widely differing research procedures and this has given rise to a certain methodological flexibility within the drawing research community. That is not to say that all methods are equally valid. The next Section explores drawing research methodology and contrasts the merits of different strategies.
Section One has discussed a number of 'perspectives' which have been influential during the establishment and conduct of the two research projects presented in this thesis. To a large extent, they act to influence the perceptions and the relevance of the outcomes and findings.

Drawing research has been presented as a young and ill-defined phenomenon emerging from a research community which is itself a new and disparate one. Sketching, it has been proposed, is part of a wider human capability for 'modelling' involving creative, developmental, communicative and evaluative strategies. Studies of sketching activity have increased recently, partly due to the impetus provided by the emergence of computer based designing and partly due to new research undertaken in institutions of art and design education.

Computer systems which support teams of remotely located specialists have been successfully marketed in recent years. These have taken advantage of improvements in communications technology and offered hardware and software at prices which have made them accessible to many. The phrase 'computer supported collaborative working' (CSCW) was coined to describe this phenomenon which was a consequence of growing commercial pressures for improved teamworking and information sharing. Industrial design is experiencing these pressures but the tools for a particular type of CSCW, which has been termed by the author 'computer supported design teamworking' (CSDT) are poorly developed - largely because our understanding of the phenomenon is incomplete. The appropriate support of sketching in such CSDT environments has received little research attention.

There is a need to understand: i) how sketches and sketching assists individual and collaborative design activity and ii) how sketching operates within computer supported design teamworking. Section 2 focuses on methods which might be used to achieve this understanding.
Section 2

Drawing Research Methodology
Chapter Five

Drawing Research Methodology

5.1 Introduction 
5.2 Strategies in Research into Computer based Sketching 
5.3 Two Cultures of Research 
5.4 Research Methods in the Programme

5.4.1 Action Research: Focused Interviews
5.4.2 Establishing Research Parameters via the NSEAD Project
5.4.3 Analysis of Graphic Acts via the ROCOCO project
5.1 Introduction

The methods for researching any given phenomenon are likely to have an important influence on the nature of the findings. This chapter explores the strategies and methods employed in some of the more influential studies of drawing in recent years and discusses the reasons underpinning the methodological decisions of this programme. Two issues are central and which guide this chapter. One concerns the relative appropriateness of research methods for assisting with the setting out of a research agenda at the beginning of a drawing research programme such as the one described here. A research approach aimed at illumination was deemed to be most relevant and the use of a focused interview technique in this is discussed below. The second issue concerns the relative appropriateness of methods for research into computer based sketching and, more particularly, research into the use of sketching within computer supported design teamworking (CSDT). The debate of this second issue highlights important procedural divisions within the research community.

5.2 Strategies in Research into Computer based Sketching

There has been debate in recent years of the relative value of strategies and methods for research into the use of freehand drawing within computer supported collaborative working (CSCW) and this is helpful in determining appropriate methods for studies of sketching within the sub-field of CSDT. Partly this debate is informed by recent but small scale studies of sketching by researchers located in art and design fields but there are other, wider influences. This debate has also been influenced by the collective output of 'design research' which is itself a relatively new research domain. Thirdly the debate has been influenced by research conducted within a broader research community concerned with human-computer interaction (HCI) including computer based communication. Perhaps, most broadly of all, the debate has been influenced by prevailing research paradigms of the cognitive sciences and the social sciences.

Cross (1992) discusses research methods which have been used in recent decades to illuminate an understanding of what he terms 'design thinking'. His summary of methods is helpful in considering relevant methods for drawing research. He summarsises the exploitation of several methods thus:

Interviews with designers
These have usually been with designers who are acknowledged as having well-developed design ability, and have usually been unstructured interviews which sought to obtain these designers' reflections on the processes and procedures they use - either in general, or with reference to particular works of design.
Observations and case studies
These have usually been focused on one particular design project at a time, with observers recording the progress and development of the project either contemporaneously or post-hoc. Both participant and non-participant observation methods have been included, and both real and artificially-constructed design projects have been studied.

Protocol studies
This more formal method has usually been applied to artificial projects, because of the stringent requirements of recording the protocols - the "thinking-aloud" and associated actions of subjects asked to perform a set design task. Both inexperienced (usually student) designers and experienced designers have been studied in this way.

Controlled tests
By these I mean the kinds of tests conducted under controlled, laboratory conditions, in which subjects are required to perform a specialised task, and data on their performance is recorded and analysed. The models for these kinds of tests are the controlled, laboratory studies of psychology research. There are relatively few controlled tests in design research.

Reflection and theorising
As well as the empirical research methods listed above, there has been a modest history in design research of theoretical analysis and reflection upon the nature of design thinking.
(Cross 1992)

In the conclusion to the collection of papers on design research arising from a workshop held at Delft University (from which the above summary of design methods is extracted) Cross highlights the lack of a shared methodology within the design research community plus a continued absence of key definitions such as those relating to design quality or success. Given this situation it would seem that the identification of methods for design research must proceed with caution and expect criticism. This may be partly due to a broad division, within the wider research community, between those researchers who follow a classical cognitive science strategy and choose to conduct studies in closely controlled conditions, and those whose sympathies lie with research paradigms of the social sciences and who argue that such studies are too intrusive to yield valuable information. HCI researchers in the latter category propose that naturalistic contexts and observational research, rather than closely controlled laboratory studies, are more likely to yield information of relevance. The division is not a minor one and is explored in greater detail in sub-section 5.3.
Given that the design research community is a varied one with little evidence of a shared methodology it is not surprising that drawing research appears catholic in its procedures. Wood (1994) identifies a broad range of strategies for investigating the functionality of graphic activity - and not merely that taking place via pictorial sketches within the context of design. He refers to studies of writers and their construction of graphic "idea-sketches" and he reports that great value is placed on the output as evidence of the cognitive activity taking place. The media itself is held to be influential in the processing of information. Methodologically, observation and interpretation are often supported by questionnaire responses provided by research participants.

Some studies of computer based drawing have frequently used video technology to record the activity taking place and the resultant output. Some studies have supplemented this with an ability to digitally capture the sketches which appear on the monitor(s) for later analysis. The use of "self-reports" has provided a helpful means by which subjects can provide meaning and explanation to their activities which assists the interpretation necessary with such drawn output (see, for example, Tunnicliff & Scrivener 1991). Goldschmidt refers to this (as Cross does) as a "thinking aloud" process and she places great value on the transcripts of such verbal output for illuminating the functions and values of sketching within computer supported collaborative working (Goldschmidt 1991). In fact she places more emphasis on these transcripts than on the drawing output which she sees as potentially idiosyncratic and often incomprehensible without explanation by their maker. Earlier studies by Bly (1988) and Tang & Leifer (1988) acknowledge the potentially intrusive nature of studies of CSCW which take place within the confines of research laboratories but they propose no methodological alternatives. Their investigation of drawing surface activities (such as drawing, pointing and gesturing) are particularly helpful since they use computer supported design teamworking as a context.

Some researchers in this area see the need to involve large numbers of studies. For example, Ballay (1987) compares the activity and output of fifty industrial designers who have been asked to undertake a simple drawing task with both traditional media and in a computer mediated setting. Ullman (1990) has used protocol analysis in long-term studies of drawing within mechanical engineering as did Goldschmidt in the field of architecture.

Views on the appropriateness of research methods seem to be directly related to the research paradigm within which certain individuals or groups operate. Important knowledge regarding the functioning of sketching within design activity has been generated by research projects which may be seen to operate under very different paradigms. Some authors support only a naturalistic or ethnographic (from the comparative scientific study of human peoples in their natural environment) approach.
Under this paradigm, studies of drawing exploit, for example, collected examples of 'real' sketch activity, often scavenged from waste paper bins, and these may be supplemented by interviews or questionnaires which take place at the end of the process being investigated. Other researchers, operating within an alternative paradigm, support the use of laboratory studies for direct observations of design activity, and particularly drawing activity, under strictly controlled conditions. Support of this technique frequently highlights the inability of the ethnographic strategy to construct valid inferences about anything other than the particular case or cases under observation. Of course, extrapolation to the 'real world' is similarly difficult with closely controlled studies where drawing and designing may take place in the isolation of a research laboratory. The 'two cultures' debate seems to be deeply embedded in drawing research and is explored in more detail below.

5.3 Two Cultures of Research

Twentieth century philosophical inquiry has sought to question the nature of scientific 'truth'. According to McNeill the natural sciences have been guilty of assuming that:

...the natural world has an independent existence of its own, which is as it is regardless of those who are studying it, and which is governed by laws which can be discovered by the research scientist if only the right methods can be developed. (McNeill 1985 p41)

Carl Hempel (1966), in his book *The Philosophy of Natural Science*, divides scientific inquiry into two major groups, the empirical and the non-empirical sciences. The empirical sciences, by which Hempel is referring to the social as well as the natural sciences, are further subdivided. They are concerned with systematic observation, interviews, surveys, psychological or clinical testing and many types of examination. He identifies the dependence on empirical evidence as the distinguishing characteristic of the empirical sciences and contrasts it with the non-empirical disciplines of logic and pure mathematics whose propositions are proved without essential reference to empirically available phenomena.

Experimentation is primarily a logical testing method requiring the formulation of hypotheses from observation or theories. Various authors have charted the exploitation of experimentation and shown its uses in a number of contexts. Parlett and Hamilton (1977) refer to its function in an evaluative methodology for educational development; Kidder (1981) examines the suitability of experimentation in a number of social research situations and Hempel, referred to above, uses a selection of medical studies to demonstrate the functioning of the methodology. In each of these cases the authors refer to the logic of the method as 'hypothetico-deductive'. Hempel's studies, using
the hypothetico-deductive method, quite openly reveal a weakness of such a strategy and show why the social sciences particularly have proposed alternative research methods. In testing the validity of hypotheses, assumptions must be made regarding the variables which pertain with any given phenomenon. These may be subdivided into those that are perceived to be controlled by the experimenter, termed the ‘independent variables’ and those that vary as a result of the actions, termed the ‘dependent variables’. An investigative strategy based on these assumptions begs two questions:

a) is it possible to identify and hold so-called independent variables steady?

b) if the identification of such variables is based on the values and assumptions of the scientist, who is to say that these values are true or correct for all times?

Thomas Kuhn raised the notion that natural scientific knowledge does not exist independently and objectively but is constructed by the science community within a framework of common assumptions which (at the risk of over-simplification of his position) he terms ‘paradigms’ (see Kuhn 1970). The aim for any given piece of research may be more concerned with illuminating the nature of the paradigm (or paradigms) rather than merely examining the phenomena which evolve under them. Thus researchers need to be confident that their methods openly reveal their value systems and fairly acknowledge the weaknesses inherent in much of the accepted research methodology.

5.4 Research Methods In the Programme

5.4.1 Action Research: Focused Interviews

Focused interviews form part of the eclectic but respected ‘case-study’ family of techniques which are themselves part of a wider strategy known as ‘action research’. As the name suggests, action research is concerned with action (solving concrete problems in real situations) and research (trying to further the goals of science) Rapoport (1970). The term was originally coined by Kurt Lewin in 1940 who advocated a cyclical research process of planning, acting, observing and reflecting where human activity was central to the subject of study. Later researchers highlight the value of action research for:

i) the improvement of a practice of some kind

ii) the improvement of the understanding of a practice

iii) the improvement of the situation in which the practice takes place.

Those involved in the practice being considered are to be involved in the action research process in all its aspects of planning, acting, observing and reflecting.

(Carr & Kemmis 1986)
Within action research the focused interview can facilitate insight and understanding which may be difficult to achieve via other research methods. It may be used in isolation or with other case study methods as part of a detailed examination of a single example of whatever the researcher wishes to investigate. It makes no claim to be representative - the essence of the method resides in the fact that each interview is treated as a unit on its own. Case study research, which includes focused interviews, may be viewed as a methodological package since it can incorporate any particular methods deemed appropriate, though the less statistical methods are more usual. Techniques can include participant and non-participant observation, various categories of interview, audio visual recording, field note taking, document collection and negotiation of products e.g. the discussion of the accuracy of an account with those involved. Sociological researchers differ on how this might be best achieved. Some adopt a very covert approach in their studies, not disclosing their true purpose, while others are emphatic that the researcher should be completely open about what he or she is doing via 'fully participant' studies.

Opportunities for extended observations are not usually available with action research and therefore the interview assumes a high profile. The extent to which any interview is focused or wide-ranging is bound to have an influence on the findings. It may be appropriate to adopt either strategy but in both cases the questions need to be carefully planned if the researcher is not to find only that which he or she set out to find! The advantages of correlating observations with interview questions and vice versa should not be overlooked. Interview strategies vary but Kidder has identified focused, clinical and non-directive as a means of distinguishing style and objectives. It is proposed that the third group are useful when:

...investigators are scouting a new area of research or when they want to find out what the basic issues are, how people conceptualise the topic, what terminology is used by respondents and what is their level of understanding.

(Kidder 1981 p178)

While a case-study approach is largely qualitative it can be used in conjunction with hypotheses. Bromley (1956) provides a salutary warning concerning the collection of information via case-studies. With reference to a number of studies drawn from the medical and psychological disciplines he stresses the need to keep fact and opinion separate, even though opinions are employed to interpret the facts.

Another important consideration in the use of focused interviews concerns the comparison of observations and statements via a process of 'triangulation' in order to note similarities or congruence in the findings. At the end of the day, however, the researcher or research team has to put a construction on the evidence and for this reason...
some researchers have advised including the ‘raw’ data as well as the interpretation when presenting the final report. In this way later researchers may consider for themselves the relationship between the interpretation and the data.

5.4.2 Establishing Research Parameters via the NSEAD Project

The research programme was initiated by an inquisitiveness regarding the functions and value of freehand drawing within design activity. If it had an initial hypothesis it was a broad one which suggested that freehand drawing supports essential design functions. This support was viewed as more comprehensive than the facilitation of mere communication - it was perceived to act fundamentally with a broad range of design capabilities associated with creativity, cognitive modelling, idea development, and evaluation as well as communication. It was believed that sketching possessed a valuable functionality for a wide variety of the creative professions but especially the design and design related professions such as those associated with industrial production, the crafts, and architecture. It was not possible to simply test this functionality because the attributes and exploitation of freehand drawing were poorly articulated and poorly defined. Also, drawing seemed to mean very different things to different people.

In the early 1980s very little had been written about the role of drawing in this context. That which did exist suffered from a lack of agreed terminology, a poor understanding of the context of design in which it operated and it was often rather particular in its focus (for example, studies confined to architecture or engineering). What was required was an illuminative strategy which would provide some definition to the phenomena and consequently allow potential directions for research to be identified. The first project of the programme acknowledged the logic of the focused interview method and it was used to illuminate the nature of drawing, and particularly freehand drawing, within designing. This was the project sponsored by the National Society for Education in Art and Design (NSEAD) and Berol Ltd. It is described in detail in Section 3. Those designers who agreed to be subjects were interviewed in their normal place of work. Each interview lasted for approximately one hour and followed a common script of open ended questions designed to allow subjects to illuminate their exploitation of drawing. Interviews were allowed to meander, to follow lines of thought which developed. This, it was intended, would allow the research and researcher to remain in the background. There was no attempt to systematically record examples of the drawing output of interviewees. Some examples were copied or photographed for the purpose of illustration of the final report but it was each subjects’ articulation which was of primary importance.
It would be wrong to refer to the work as a typical example of action research since it did not contain the variety of investigative methods nor the triangulation of findings which would be normal in such research. An extended period of observation of each subject would have been helpful in order to view their exploitation of drawing and to compare this with the verbal analysis of the formal interview but this was not practical. However, the research was successful in providing illumination of a number of functions for drawing. One aspect of research quality comes from the richness of the articulation presented in the transcripts and for this reason the resulting transcripts are appended to this thesis so that they may be read in conjunction with the analysis and interpretation. This project provided the ideal foundation for subsequent research. Indeed it may be argued that the NSEAD / Berol project provided the only logical strategy given the ill-defined nature of the research problem. The subsequent analysis of graphic acts, made possible as a result of the ROCOCO laboratory studies, was founded on the illumination of phenomena provided by the NSEAD work. It highlighted drawing strategies, clarified usage of terms, revealed commonalities in working practices and provided evidence for valuing drawing within design activity.

The NSEAD inquiry did not seem to generate knowledge in the classically accepted ways. Partly the understanding emerged slowly - rather like putting together pieces of a jigsaw - as commonalities were found within the transcript data. Partly pictures 'clicked' into place during the analysis of the transcripts. This illuminative advantage of the strategy should not be dismissed lightly. An alternative strategy based on in-depth studies of known drawing practices might have missed this. Opportunities to test observations were limited. There was some attempt to allow each interview to inform the conduct and substance of subsequent ones but no real analysis was undertaken until all the interviews were completed. The transcripts of each interview were not available before the end of the interviewing phase.

This Chapter continues with a discussion of the methodological issues of the second of the two research project presented in this thesis. The next sub-section introduces what has been termed 'graphic act analysis' and proposes its use for investigations of drawing behaviour when designers are required to act collaboratively on a shared design problem. The project titled Analysis of Graphic Acts (AGA) was based on a revisiting of graphic and video material generated by the ROCOCO project which took place at Loughborough University between 1988 and 1992. The ROCOCO project, which is described in more detail in Section 4, was largely unconnected with the NSEAD project. It had a wider remit than the first project and involved a larger number of researchers.
5.4.3 Analysis of Graphic Acts via the ROCOCO project

The author was part of the ROCOCO project - a multi-disciplinary team working in the research field of computer supported collaborative work. The project had a considerably higher level of funding (from the Science and Engineering Research Council & the Department of Trade and Industry) and it necessitated a higher level of organisation than the earlier NSEAD project. The research concerned many aspects of co-operation and collaboration within computer based environments. While drawing was of primary interest to the author, other researchers were keen to investigate verbal communication and other forms of non-verbal communication, such as gesture, plus the nature of interaction between modes of communication.

The ROCOCO project proposed to contrast, via closely controlled studies, the nature of the communication between pairs of subjects working proximally, that is, face to face, on industrial design tasks (termed Phase One) with similar pairs of remote subjects who were linked by computer technology (termed Phase Two). The studies aimed to identify and control the independent variables (such as design ability and modes of communication) so as to better understand CSCW and, particularly, to document the effects (via dependent variables) of impoverishments to the modes of communication. The research enabled conclusions to be drawn concerning the differences between CSCW and proximal working. It also facilitated conclusions regarding the relative value of modes of communication (including sketching) within CSCW. Phase One consisted of six one-hour design sessions, each undertaken by a pair of second year Design and Technology students as subjects. Phase Two consisted of twenty similar subject pairs but this time they were remote from each other and linked by computer based technology. Four conditions were established in Phase Two, each offering different permutations to the communication channels. These channels included 'video' (enabling subjects to see each others expressions and gestures and to show items); 'drawing surface' (enabling subjects to make and share drawings via specialist software); and 'audio' (using a headset telephone to enable subjects to speak to and hear each other). In this way hypotheses could tested regarding the nature of computer supported communication.

Much of the work of this project lies outside the remit of this thesis. Little is said here regarding the findings concerning verbal communication and gesture since these were the province of other researchers. This thesis confines itself to an overview of the research project plus a detailed examination of those matters pertaining to drawing. There is a considerable emphasis on revisiting the data generated by ROCOCO to both confirm the findings and to look for new relationships which did not form part of the original project. This revisiting process and the subsequent new analysis is referred to as the Analysis of Graphic Acts (AGA) project. It is proposed that the thesis and,
indirectly, the wider research field of 'drawing and designing' benefits from these two distinctly different research projects with their differing empirical techniques. The illuminative NSEAD study provides direction and context for subsequent research. The ROCOCO and subsequent AGA projects provide detail on the conduct of sketching in collaborative design not available elsewhere. The ROCOCO and AGA projects generated considerable data and both exploited statistical techniques for interpretation. The AGA project made use of the computer based Statistical Package for the Social Sciences (SPSS) and thus the project was able to generate very different output compared to that of the NSEAD project. Nevertheless, commonalities emerge which present the value and use of freehand drawing in collaborative design. Graphic act analysis is shown to be an appropriate technique for comparing the use of drawing by simple design teams in two different conditions. It highlights significant new understanding regarding computer based collaborative designing. While the use of student subjects for the ROCOCO project may give rise to questions concerning the ability to extrapolate the findings to the wider design community the work is presented as beneficial to researchers in the fields of drawing and computing; to the industrial design profession and particularly to the manufacturers of future systems for collaborative designing who may each be better informed regarding the value and functioning of freehand sketching in modern product design and development.
The methods for researching any given phenomenon are likely to have an important influence on the nature of the findings. Design research has been presented as lacking a common paradigm and this has implications for determining appropriate research methods for studies involving design activity. Furthermore, it has been proposed that a broad methodological dichotomy exists within the drawing research community and particularly that research concerned with investigations of sketching within computer supported collaborative working. Some researchers favour a classical cognitive science approach exploiting studies of sketching activity in laboratory conditions. Others highlight the distorting effect of such studies and prefer less intrusive, ethnographic styles of investigation such as various types of observation. Researchers have placed emphasis variously on verbal records, discourse transcripts, video recordings, graphic output and questionnaire responses and each have their own advantages.

It has been proposed that this programme of research has a foot in both camps. The NSEAD project uses a focused interview technique to illuminate the broad functions and value of drawing and sketching for various designers and this is presented in detail in Section 3. The AGA project is based on an earlier multidisciplinary project titled ROCOCO and is presented in Section 4. The AGA project revisits the original ROCOCO material to produce new data and new findings regarding the output of sketches during collaborative industrial design activity. It does this via a process of graphic act analysis. This empirical technique makes use of the SPSS computer based statistical package to identify significant differences in the data deriving from studies of proximal and remote collaborative designing.
Section 3

The National Society for Education in Art and Design (NSEAD) Project
## Chapter Six

The NSEAD Project: Introduction

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6.1 Background

Each year the National Society for Education in Art and Design (NSEAD), in collaboration with Berol Ltd., offer an open bursary competition. In 1987 a research proposal was submitted by the author which was founded on the belief that there was a less than complete understanding of the functions and value of sketching in the emerging subject of design education in schools. This situation was compounded by anecdotal evidence which suggested that articulation and analysis of sketching activity emerging from design practitioners was very limited. It was proposed that this significantly hindered design awareness for individual students as well as limiting the development of the subject at all level of education. Furthermore, sketching in various design curricula, as well as in related subjects such as art, was under threat from the widespread exploitation of Information Technology (IT) and the movement to integrate computers into classroom teaching and learning. Without research to justify and support its continuation, and to establish its relationship with IT, there was a danger that the teaching of sketching would become marginalised in busy curricula. The proposal was awarded the 1988 NSEAD/Berol bursary prize which provided funding to undertake the research.

6.2 Project Aims and Objectives

The research bid was founded on the perception that drawing, and particularly freehand sketching, was a widely exploited but poorly articulated phenomenon within a number of design and design-related activities. Whilst there was a perceived need for investigation it was not entirely clear what the parameters of the subject were. Neither was it clear what the central research issues were. Thus the research aims for the NSEAD/Berol bursary project were:

i. to illuminate the phenomenon of drawing and sketching with reference to a broad spectrum of design-active professionals

ii. to present new knowledge concerning the use, functions and value of drawing and sketching for various designers and design teams and onto which could be built more specific research projects

iii. to establish a better understanding of the interface between sketching and computer based design practice both in industry and in education.

The objectives were:

i. to undertake focussed interviews with a selection of experienced and expert design practitioners and to document the output as a series of transcripts.
6.3 The Research Proposal

The bid to the NSEAD/Berol bursary competition proposed to examine, via focused interviews, the functions and value of drawing for 20 people who were well established in various design and design-related professions. They were to be selected on the criteria that they were widely respected as designers and that they frequently generated sketches in the execution of their design work. It was important to the research aims that the subjects came from a wide variety of design specialisms because if the findings were to have any generality they would have to reveal a significance for drawing across a spectrum of design practice. Some of those initially approached were known to the author. Others were discovered from research papers or publications in the field of drawing and sketching. Still others were suggested by various members of the bursary interview panel who had a wide interest and experience of the subject. It transpired that 18 people were identified for interview which amounted to the number of positive replies to the initial letter of inquiry. It was proposed that the transcripts of the recorded interviews would be analysed, interpreted and published.

The research was always intended to be an illuminative inquiry having more in common with observational and other ethnographic studies found in the human sciences than the experimental techniques of the natural sciences. The research could have been undertaken in alternative ways. It could, for example, have documented the drawings of each subject; it could have required each one to undertake a set drawing exercise or it could have examined less people much more closely. Each of these presented disadvantages to a project which was seeking to explore the parameters of an ill-defined phenomenon. Knowing one subject’s strategy in depth would not have provided the general illumination required. The focused interview technique was selected since it was most likely to illuminate the broad practice of sketching, highlighting issues which might be significant, and which could subsequently provide direction for future research. Prepared questions provided structure and consistency to the interviews but interviewees were allowed to digress. Questions were deliberately phrased to encourage a broad range of responses.

6.4 Research Procedure

The interviews took place between August 1987 and August 1988. Most interviews took place at the subject’s normal place of work. In some instances interviews were conducted with more than one subject present. Richard Seymour and Dick Powell
were interviewed this way and their responses influenced each other in a helpful and constructive way. Similarly O’Leary, Webber and Matthews were interviewed together in a single session. Each interview was intended to last for one hour but some were slightly shorter. The interview schedule consisted of a hierarchy of questions from very open questions to very specific ones. Some questions were designed to put the interviewee at their ease; others were designed to seek explicit information about drawings and drawing activity. The precise wording of questions varied across interviews because an attempt was made to use the terminology arising from the interviewees. Similarly the interviews were permitted to meander to follow potentially useful lines of inquiry but in each case the schedule of questions guided the overall direction. Each interview began in a consistent way. Subjects were asked to describe their work and/or their design background. Early questions explored their perceptions of their own design activity. After this introductory phase the questions then focused on drawing such as how do you use drawing in your design work? or how and why is sketching important in your design work? At this point the discussions establish their own agenda but meet the overall aim by providing a rich illumination of the subject.

All interviews were recorded on audio cassette tape and a transcript was made of each by a research assistant. These were edited by the author to remove unnecessary verbal ‘noise’ such as ‘um’ and ‘err’ and the occasional repetition of a response but are largely a complete and full record of each interview. Subjects were not permitted to edit the transcripts which are appended to this document. Where reference is made to these transcripts the page number of its location in Appendix I is given.

6.5 Research Subjects

The interviewees included a wide range of experienced practitioners. The full list of subjects is provided below:

Subjects for the NSEAD / Berol bursary research project

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peter Ashen</td>
<td>Head of Department of Furniture Design, Birmingham Polytechnic (now the University of Central England)</td>
</tr>
<tr>
<td>John Aston</td>
<td>Head of Graphic Design, BBC Television Centre, London</td>
</tr>
<tr>
<td>Royden Axe</td>
<td>Director of Concept Engineering, Austin Rover (now Rover Group), Coventry</td>
</tr>
<tr>
<td>Ian Ballantine</td>
<td>Architect / Lecturer, Glasgow School of Art</td>
</tr>
<tr>
<td>Clifford Bowen</td>
<td>Sculptor / Lecturer, Glasgow School of Art</td>
</tr>
</tbody>
</table>
Mike Fuller  Architect / Director, Pick, Everard, Keay and Gimson, Leicester
Pamela Howard  Theatre designer / Head of Department, Central School of Art, London (now The London Institute)
Patrick Ireland  Freelance illustrator, Maidenhead
Rod Kelly  Silversmith, Norfolk
Sheila Kelly  Jeweller, Norfolk
Imogen Margrie  Ceramic sculptor, London
Sally Matthews  Sculptor, Loughborough
Norman McNally  Product Designer, Course Leader - Industrial Design, Glasgow School of Art
Paul O'Leary  Consultant designer, Loughborough
Dick Powell  Product Designer / Director, Seymour-Powell, London
Richard Seymour  Product Designer / Director, Seymour-Powell, London
Claire Webber  Artist, Loughborough
Rick Wells-Cole  Architectural assistant, Pick, Everard, Keay and Gimson, Leicester
Alan Williams  Product Designer / Director, David Carter Associates, Warwick.

6.6 Data Analysis

The transcripts were analysed by the author only. The analysis consisted of several readings of each transcript to look for commonalities and significant differences. It is in the nature of the research method that the most significant findings may not be those which are raised most commonly and therefore a non statistical approach was adopted. The illuminative technique allows emphasis to be placed on those responses which are perceived to shed most light on the phenomenon under observation. Thus while the commonalities were sought and grouped together under provisional headings - being redistributed and relabelled many times - the analysis and interpretation makes generous reference to one-off or statistically small occurrences of some observations. Consequently, a number of quotations are taken from the transcripts and presented in the analysis. From this analysis of the general and the particular a number of issues emerged within each of two broad categories - design communication and design development. The research made no attempt to look for differences in opinion as a function of, for example, success, age, gender or profession due to limitations on available time and the very small sample of subjects used.
6.7 Introduction to the Findings and Discussion

Given the nature of the research inquiry it is logical to combine the presentation of the findings with analysis, discussion and comment. What emerges from the transcripts is a clear and unanimous support for sketching within a broader mix of strategies and techniques which make up design activity. Equally clear is a broad distinction between sketching which supports communicational objectives and sketching which facilitates creative and developmental objectives. Section 3 continues by presenting the findings and discussion with this distinction imposed. Chapter Seven focuses on the use of drawing and sketching to support communication and attempts to link the NSEAD work with other published analysis. Chapter Eight moves into less charted territory with its presentation of findings and discussion concerning how sketching appears to support fundamental and often internalised processes of creative design and idea development. Chapter Nine concludes the Section with a review of the overall findings from the NSEAD project and this provides an opportunity to link the functions and values explored in the preceding chapters.

In spite of the breadth of disciplines exhibited by the research subjects there was unanimous support for the importance of sketching in design and design-related activities. Not only were sketches viewed as products in their own right but sketching was presented as a valuable activity in the poorly understood process of resolving design problems. For a spectrum of designers sketching was viewed as an essential tool for the very organisation of thought. At the time of the research Aston had the influential position of Head of Graphic Design at the BBC in London and he states that he would 'never appoint anyone who had not got very strong drawing skills' (A15). For those seeking to enter one of the design professions an education in drawing is seen as essential. Ashen was not alone in believing that those early years spent learning drawing were 'perhaps the most valuable years of the whole of my education' (A4).

Why it is that such people view drawing and sketching as a vital aspect of designing forms the substance of this chapter. All of those interviewed stumbled at some point or other in their attempt to articulate the functions and value of sketching activity. It was as if some phenomena were beyond verbal communication and it has given rise to a series of transcripts which are rich, if somewhat meandering, in their presentation. However, many of the comments are insightful and perceptive and the focused interview has proved to be a very valuable technique for this project.

There exists a great deal of literature on how and why information needs to be communicated. Many of the subjects were able to dissect the phenomenon of communication and discuss its importance for them. However, communication is only one of the purposes of drawing within design activity. Design necessitates creativity and this may often be a private activity. The subjects displayed a widespread
exploitation of drawing even when it was anticipated that no other person would view this output. In such cases communication to others could not be the primary objective for such graphic activity but it may have something to do with a personal construction of an appropriate response to a given area of inquiry. It is this area which desperately requires analysis and articulation and it formed the focus for some of the questioning during each of the interviews. As introduced above, sketching and communication appears to present a well defined and understood relationship. Issues in this field, from a number of sources, are discussed in Chapter Seven. The role of drawing in the creation, formulation, manipulation and improvement of ideas is discussed in Chapter Eight. It is intended that the study will reveal the broad overlap and inter-relationships which exist between these functions and this is brought out in the final chapter of the Section (Chapter Nine) which presents the project findings.
Chapter Seven

The NSEAD Project

Findings and Discussion: Drawing and Communication

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7.2 Communication as Sharing, Exploring and Filtering 86
7.3 Communication: Conventions and Symbols 87
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7.1 Introduction

As proposed in Chapter One, perhaps the most accepted and readily understood capacity of drawing is its ability to convey information from one person to another. Design activity relies upon successful communication for the identification of requirements, the sharing of ideas, the confirmation of understanding and the evaluation of proposals. The six communicative functions of drawing as defined by Ashwin in Chapter One are helpful but Ashwin fails to stress the central operational issue which is that rarely are any of them used in isolation. Even when a drawing is intended to possess only one function other perceptions by viewers (who may include clients, colleagues, students etc.) create a wider functionality.

The subjects of the NSEAD project provide some anecdotal evidence of the existence of Ashwin's function categories but, more importantly, reveal the operational pluralities in professional design practice. Just as natural language may contain ambiguities, providing potential pitfalls for linguistic research, so graphic imagery can have many simultaneous functions and thus it requires caution before easy categorisation. A drawing which is produced explicitly for referential purposes, for example for the communication of the components of a particular artefact, might be used, in a different context, to illustrate a particular profession or be admired for its graphic skill or interpretation. The same situation pertains for drawing within design activity. The danger with identifying certain 'types' of drawing is that any one drawing may reveal, simultaneously, many permutations of Ashwin's functions. This is compounded by different perceptions of functionality between the draftsperson and the viewer(s). Its function may also change over time - whether this be a minute by minute change or one which takes place over generations (for example, note the current interest in the functionality of the sketch output of Leonardo DaVinci which surely goes beyond anything the artist may have intended). The lesson is that any attempt at categorisation of drawing functionality needs to proceed cautiously.

The capacity for drawing to communicate is most readily accepted even if the manner of its functionality is less well understood. It is the most public and the most marketed capacity of drawing. Design publications in fields such as graphic or product design display ample examples of slick images and manuals of technique - the 'hows' of drawing, but little which discuss drawing as a tool for better designing - the 'whys' of drawing. It may be that this reflects communication as the most comprehensible of capacities. Certainly the research subjects in the NSEAD project reveal a consensus of opinion with regard to the value of drawing for conveying or relaying information.
7.2 Communication as Sharing, Exploring and Filtering

The industrial and commercial requirements for fast, efficient and accurate communication have given rise to new trends in computer based working. Royden Axe, referring to his work at Rover, identifies a significant trend towards replacing manual drafting and drawing with computer based modelling techniques - a trend mirrored in all mass manufacture vehicle companies and many other consumer product industries worldwide. The driving force would appear to be a commercial pressure for a particular type of communication, namely the ability to share and separately update graphic referential information across a broad spectrum of specialists. However, the trend towards computer based working is not so observable in those areas of the vehicle industry concerned with creative design such as styling or interior trim where freehand drawing and rendering are retained for their unique emotive and conative functionality. Information sharing would seem to be well developed - idea sharing on the other hand appears less easy to arrange.

Both Williams and Seymour discuss the importance of drawing in their communicative activity and feel that for them it is the most successful and appropriate means to convey their types of information. McNally develops this further by indicating that communication is a responsibility and not just a preference for the designer. More importantly he identifies two types of communication:

Designers have a primary duty to communicate their ideas to others, this is part of why they are working, they have to convince others that their particular picture is valid and valuable. Also for their own ability to progress the work from a blank page to a working concept they have to be able to make marks which are satisfying and convincing in their own terms'. (A90)

Fuller quantifies his application of communicative strategies with reference to his work as an architect. He estimates that 90% of his time is engaged in communication of one type or another and he suggests that drawing makes a significant facilitator. However, McNally’s distinction between drawing to communicate to others and drawing to communicate to oneself prompts a deeper analysis. It is easily overlooked when examining the phenomenon that a personal dialogue - a conversation with yourself - involving externalisation and interpretation of information, might be viewed as communication. Almost half the subjects referred to such private communication during the discussions and, of these, all rated it highly important to successful designing. Ireland is one of many who could easily distinguish between the work he produced to communicate to himself and that which he saw as communication to others. Whilst those illustrations which are submitted to, for example, an art director exhibit certain qualities, his personal work is very different:
I always sketch when I am working out any layout, it is always a series of very quick sketches which I probably wouldn’t show to anyone. It is always only for my own use. (A59)

Similarly, Bowen reveals a requirement for private communication:

Generally speaking I tend to do drawings which are ostensibly for myself in that they are communicating about ideas in that very close and private way of artists, but I have always got a sense of there being another person looking over my shoulder. (A38)

Why it is that designers feel this need to externalise and represent graphically their own thinking is taken up by Seymour:

... there are very, very few people in the world who would, I suspect, be able to conceive it all in their head and have no drawing ability whatsoever. I think it would stop there a lot of the times because they would hit a stone wall of communication, both with themselves but more importantly, with the outside world. They wouldn’t be able to express themselves. (A96)

Such personal communication has much in common with strategies for the exploration and manipulation of information and these are explored later. As discussed above, some drawing strategies exhibit several functions, some simultaneously, some sequentially; some supporting intended cognitive processes others perceived only by viewers. For example, drawing activity may be attempting clarification or filtering of information, idea generation and externalisation of thought in addition to explicit communication to other people. An illustration of this is provided by Aston who describes a type of drawing he produces in early client meetings:

As they are talking I am usually doodling, a peculiar kind of doodling, I suppose, because the one thing I must not allow myself to do is start designing per se because I’m going to assign one of our fifty or so designers to it and he or she wouldn’t thank me very much if I had already caused some prescription to happen. (A12)

7.3 Communication: Conventions and Symbols

In contrast to Seymour, McNally believes the central role of drawing is in communication to oneself and he encourages the development of greater graphic skill in order to be able to achieve such communication with greater quality. He goes on to dispute the notion that the only communicative ability a (product) designer requires is
via the traditional, formalised drawings of the engineer. He views conventions, for example British and European drawing standards, as a means of ordering communication between a relatively small number of specialists operating in a much broader activity. Ballantine - also at Glasgow School of Art but from the School of Architecture, makes a distinction between the value of different types of drawing conventions. Whilst criticising formal perspective drawing he sees value in other types of formalised drawing conventions:

Strangely enough the Mackintosh School has not encouraged perspective drawing... because, I think, they are overly beguiling. They are rather like cartoons of buildings, they can take significant bits of the buildings and over-emphasise them; they can play down other parts of the building which ought to be more carefully referenced, identified and studied. Orthographic and... axonometric drawing are much more important to us than perspectives which we see as a public relations job. (A33)

The importance of referential drawing techniques within design education receives widespread but cautious support. Ashen, for example, could foresee a situation where engineering conventions could stifle important design capabilities:

I don't think you can conjure up ideas in your mind about how to construct something, unless a visual literacy has been awakened in the first instance. I doubt very much if that visual literacy would be awakened through technical drawing. (A6)

A great many of the subjects acknowledge various types of drawing which operate somewhere between very formal graphic conventions on the one hand and very idiosyncratic mark-making on the other. Designing in all its manifestations involves negotiation and communication with a broad community and drawing styles may have to adapt to suit the perceived recipient. Production managers, marketing departments and design staff may have differing understanding of any symbols used and may require very different types of graphic communication. Aston refers to drawing within teams in the field of television graphics. Typically specialists including technical coordinators, computer graphics programmers, animators, illustrators and artists exploit drawing as a vital means to share, and thereby come to understand, each others contribution - not least so that each can be costed and a budget agreed. McNally indicates a respect for the international conventions which form the symbolic language of engineers but highlights a designerly requirement for communicating incomplete or imperfect 'visions of the future'. Such visions are presented by Bowen as the products of a less documented but equally profound language and with which designers are expected to demonstrate varying levels of fluency. Ireland identifies a requirement for
fashion journalists to be able to communicate their observations to fashion editors and graphic designers. The sketch output generated between these separate professions reveals the development of a fast and efficient but nevertheless complex drawing style involving shared symbols.

It would appear that the phenomenon of specialization inherent in contemporary manufacturing industry heightens the requirement for a common language. Dick Powell, himself an author in the field of drawing for designing, refers to his consultancy’s increasing contact with manufacturing companies where there is an expectation for the consultant to immediately operate within the established systems of communication between, for example, in-house engineers, materials technologists and marketing departments. He not only indicates that graphic strategies may provide a common denominator for such communication but that a designer skilled in sketching can operate as a catalyst for the encouragement, coordination and documenting of group working:

When we go into a big company like (example removed)... the one thing they don’t have is someone who can draw so you have got a terrific weapon. You can sit down at a meeting and say “we can do it like this” and as soon as you start to do it they say “how do you do that”. *(A99)*

Clearly drawing is acting as a means for Powell to communicate his perceptions and ideas but he is also providing a means to visualise the verbally expressed opinions and suggestions of others present at the meeting. It may be that this ability to externalise the thoughts of others, to make public that which is private (or at least only public in a verbal sense), and to allow teams to operate developmentally as a result of the graphic logging of output can form a major contribution to groupwork activities. This is further developed in the following sections but it is important to establish here that drawing can assist verbal communication. Aston provides an anecdote to illustrate this. He describes the importance of paper tablecloths at the Television Centre staff cafeteria which were for a short-lived period replaced by ‘up-market’ linen ones:

If you were sitting at a table with designers they would constantly draw. At the end of lunch the whole paper tablecloth would be simply covered in drawings - not because they are vandals, but simply because it is the easiest way to ‘talk’ to people. *(A17)*

Ashen provides similar anecdotal evidence:

I worked for a time with Professor Dick Russell and he did very little drawing in a formal sense but when he was talking to you he was also drawing. In a way he
was not only conveying ideas to the people who were responsible for developing the designs but he was testing his own ideas at the same time. (A7)

7.4 Sketching - An Integrated Communications Package

Freehand drawing provides designers with a profound communicative tool on which a great deal of reliance is placed. It would appear to go beyond Ashwin's function categories as discussed in Chapter One - particularly regarding the pluralistic manner in which communication operates with other modes of communication and with other, private, drawing functions. As Williams admits: 'with a pencil in my hand I feel whole and I am only half a person without it - I am restricted to speaking about the design' (A107). Communication via sketching exhibits a richness extending way beyond a simplistic exploitation of agreed conventions. Some drawing conventions are more transparent than others and Pamela Howard appears to introduce a graphic personalisation into her drawings for theatre set designs with a subsequent qualitative improvement in communication:

I just know (that) the best collaborations I have with directors often come from the fact that I have done very good drawings. Even though the ideas may not be thoroughly developed, a sense of the quality in the production and the quality of my work is conveyed through the kind of drawing that I do. (A53)

Clearly then, communication via drawing operates on a number of levels in addition to working alongside other functions. The lack of published information on this relationship has not gone unnoticed by the research community but as a result the level of debate is thin with a consequent scarcity of useful guidance filtering down to fields such as design education. The next section moves into less well charted territory and presents analysis regarding functions of drawing other than for the communication of information to others.
Chapter Eight

The NSEAD Project

Findings and Discussion: Developmental Functions of Drawing Within Design Activity

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8.4 Drawing and the Exploration and Manipulation of Ideas 98
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8.1 Finding and Responding to Design Problems

It is quite clear that designing and creativity exhibit a very close relationship. What has not been made so explicit is the relationship that drawing has with creativity across a broad spectrum of design activities. Webber, Powell and Aston each highlight a creative, developmental function which drawing provides for them in their design practice. Powell provides a helpful introduction to an analysis of this phenomenon when he states that:

one is a more creative person if you draw ... because you can have this conversation with yourself, you can express your ideas to others and you can organise your thoughts better. (A96)

The notion of ‘conversing with yourself’ was introduced in the previous chapter and its complexity is compounded by the variety of reasons for which such a personal dialogue may be used. As McNally puts it: ‘answering the problems, making the right moves, constructing the right structures and asking the right questions’ (A91). Perhaps Bowen’s reference to his use of drawing as a means of ‘assimilating information’ (A37) provides some illumination. He presents drawing as a means of turning over fresh information, a way of trying things out and a way of consolidating a theme or thought. Bowen uses the term ‘homing-in’ which appears to extend the role of drawing from a problem-resolving device to include a problem-finding one. It seems clear then that drawing requires a more detailed examination if the problem finding potential is to be made explicit.

If creativity does involve the searching out and discovery of new problems or the rephrasing of problem definitions as promoted in Chapter Two, then the interviews provide considerable evidence of a supporting function provided by sketching. Freehand drawing is presented as a key tool in the creative act of problem-finding. The architect and lecturer Ballantine categorically states that ‘the whole process of drawing is to do with identifying very clearly what the problem actually is’ (A30) and he goes on to stress as Einstein did, that the solutions to problems are much less important than are the definitions. Similarly Williams uses sketching to assist the definition of problems: ‘If I go and see people and talk about potential problems, I always end up with a pencil in my hand, drawing the problem’ (A107). It appears that those involved in design education are particularly concerned to attempt an articulation of this relationship. Ballantine and Howard examine the portfolios of drawings of prospective candidates for their respective higher education institutions not to assess the finished product but for an indication of the candidates approach to those problems with no immediate solution. The difficulty of comparing examples of such problem-finding drawing produced by students and experienced designers is highlighted by Ballantine.
He presents the case for viewing the marks made by one with a mature design ability as necessarily different from those made by a student of design. Ballantine uses a delicate analogy to describe the diminishing distance between problem identification and resolution for a maturing mind. He likens the experienced designer to a poet who no longer has to struggle with articulation: the words and the images ‘offer themselves to his mind to express his emotions’ whilst a young student is always having to proceed in ‘backwards and forwards movements’ (A34).

8.2 Critical Judgement and Creative Insight

A particular exploratory function of sketching is presented by Ashen, who also has considerable expertise in design education. He promotes the activity of observational drawing as a means of exploring, understanding, remembering and, particularly critically judging. Raising the awareness of quality, detailing and proportion are presented as vital to the development of a visual literacy and Ashen holds that drawing provides the appropriate means of achieving this. This is echoed by Fuller. As an architect he believes that when you draw you ‘look at things more thoroughly, in a much more concentrated way than if you don’t draw’ (A44). Perhaps it is that architects have a particular need or developed ability in this area. Certainly he believes that drawing practice provokes many architects to scrutinise building details during their street walks. It is interesting to note here the consensus of opinion between designers and artists. Whilst the end product is likely to be vastly different, Matthews, as a sculptor, points to drawing as an aid to understanding. Observational drawing is, for her, a phenomenon of line. She refers to line drawing as ‘tracing’ a given object in her minds eye in order to understand it better: ‘I draw to help me understand. It’s rarely used to express myself. It’s learning about what you are looking at ... and being surprised’ (A50). The final point suggesting a process of revelation in addition to less dramatic learning approaches.

Such analytical and exploratory drawing appears to increase the potential for discovering or ‘seeing’ new information. Obviously an individual’s creative potential will have a bearing on this but the transcripts reveal a widespread exploitation of a process of deliberate or planned graphic encouragement of creative thinking. Articulation appears most strained in the communication of this notion. Subjects refer loosely to ‘feeling’ or ‘expression’ in drawing - even that which, on the face of it, is part of a controlled and systematic design process.

Howard acknowledges her use of such provocative graphic strategies and views drawing as an external expression of an internal response. This belief in drawing ‘making a response’ forms a very important component in her work with young theatre designers. She continues:

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We encourage people not to try and think out the solutions before they draw but to start with a blank piece of paper, start making lines, putting colour on a piece of paper, making marks ... and through that discovering something about the feedback process of drawing. (A53)

Clearly this may not provide a useful strategy for all designing but the intuitive approach does receive support from a number of quarters. It may be anticipated that a sculptor such as Matthews defines her successful drawings as those which 'seem to catch what you want' (A77) because of the traditional interpretation of creative work within the fine arts. However, such a deliberate and structured approach is mentioned by others who are involved in other applied or commercial activities. Ballantine refers to the importance of free discourse in the creation of architectural concepts and he highlights the thumbnail sketch as both evidence of, and catalyst for, such cognitive activity. Similarly Axe sees a long-term future for the notorious marker pen renderings of the automotive industry (see Figure 3.1) simply because there are no other means sufficiently well developed to capture the essential 'caricature' of the designers intention.

Another three-dimensional designer, Ashen, offers some development to this theme and he begins to indicate the profound links between drawing as a personal, exploratory or inspirational activity and drawing as an externalising activity where images communicate conceptual development:

One has to say that if you have an idea in your mind, it is very rare if that idea is seen in the round. The idea may revolve around a structural idea - an idea of the use of materials, even some stylistic detail that you are interested in, but I always maintain that it is incomplete until I have got it down on paper and have drawn it from different points of view. As soon as you start drawing it you realise how inadequate your mental image is. You think you have got it contained in your mind but as soon as you put it down on paper you recognise there are facets of it that you can't really grasp just by thinking about it. So it is the first externalisation of an idea to test it. (A5)

Such graphic discourse, whilst seen as important, would appear to be less easy to teach. Seymour identifies the randomness of much sketching activity and terms it a ‘flow of consciousness’. Lack of inhibition may be a prerequisite for such a flow to take place as suggested by Fuller and this would support the inclusion of certain developmental activities within design education which attempt to reduce inhibition.
Fig 3.1 Typical marker renderings used in the car design industry (supplied by Royden Axe, Austin Rover.)

Section 3 Chapter 8 The NSEAD Project: Drawing & Development
8.3 Graphic Ambiguity and the Development of Skills

Somewhere between the analysis of the problem and the conscious exploration of proto-solutions lies a cloudy perceptual domain within which designers refer to sources of motivation or inspiration that result from quick sketches they have made. Certain sketches are produced within which reside sufficient ambiguity for the mind to see no single subsequent move. Rather the ambiguity facilitates several interpretations. Thus a creative analysis is begun which appears to display some congruity with Tovey’s cognitive processing model referred to in Chapter Two. There is some support for the importance of ambiguity. Bowen, for example, refers to his reliance upon drawings with flexibility, ‘drawings which can be interpreted in a number of ways’ (A39).

Central to this issue is the deliberate reduction of preconceived ‘meaning’ without the sacrifice of ‘feeling’. Margrie illustrates this point when she discusses the nature of her drawn studies made at London Zoo in preparation for the construction of a ceramic sculpture:

I like the movements of the birds and it is very difficult to draw them. I might make just a quick squiggle. I end up with a line which has a feeling...
Sometimes it’s a feeling from the bird, perhaps it is aggressive or cheeky...
There isn’t anything definite, it’s just a feeling I want to get over. (A74)

Matthews’ exploitation of drawing in a search for feeling implies an almost spiritual dimension to graphic activity - not least that drawing supports the generation of the spirit of appropriate types of responses without imposing the heavy hand of well defined solutions. As Seymour identifies ‘the wonderful thing about drawing ... is that you can generate a spiritual conception of what you are doing, you can erect the spirit of something in a sketch’ (A94). Ballantine offers support for this viewpoint with reference to one of the great designers of the Twentieth century:

Alvar Aalto did very, very sketchy, embryonic, schematic drawings which were purposely ethereal because he was trying to catch what you could only call the spirit or the essence of the job. He did not wish to compromise solution by seizing on form too quickly. (A32)

Underlying this exploitation of drawing as an exploratory tool is a fact which should not be overlooked. This is the sheer enjoyment in drawing exhibited by the subjects. Many stated that they would most likely draw whilst designing whether or not they foresaw a distinct function for their drawing. Some found their drawings appeared apparently unconsciously during meetings or conversations. There are sufficient telephone pads around the world crammed with doodles to give some credence to Kelly’s opinion that drawing can be organisational, creative and involuntary. It is
difficult to isolate the functional requirement to draw from this inner motivation but a significant proportion of the subjects expressed the feeling that they were unable to stop themselves from drawing as they talk, listen or create.

In addition to using drawing as an aid to learning, Seymour refers to drawing as an ‘immensely gratifying’ activity and this seems to be the result of capturing something that eludes words. The enjoyment of drawing as a hobby or pastime was also widely quoted. Whether the ability promotes the practice or vice versa is unclear, but the majority of those interviewed regularly made time to maintain their graphic abilities through recreational sketching or painting. Howard, Margrie, Ireland and Fuller all refer to the frequency with which they draw and many of the remainder stress their pleasure in drawing during infrequent vacations. The practice may be formalised such as the life drawing classes attended by Ireland, or informal as discussed by Williams, who keeps a sketch pad in his car and who expresses enjoyment in drawing birds and stones. It was this latter interview that perhaps most successfully explored the relationship between recreational sketching and an exploitation of drawing within the pressurised, commercial world of design. In this, Williams highlights the very great importance of ‘inquisitiveness’ to the designer. ‘If you lose interest you might as well pack it all in’. What is important here is the relationship that Williams presents between the importance of inquisitive sketching and the development and maintenance of cognitive skills essential to designerly thought. If inquisitiveness is associated with being pro-active and with strategies for problem finding, creativity and the comparing of information of many types then it may be viewed as an important mental capacity for designers. ‘I think your level of inquisitiveness drops off if you are not constantly looking and thinking and sketching about a notion or thought’ (A110). Ashen also presents an interesting analysis of the desire to draw:

When I went into the army I continued drawing. I’ve got sketchbooks full of drawings, simply because it was a means of coming to terms with the world around me: new landscapes, new situations, new people. It seemed to me a way of making contact in a very real way. (A5)

The relationship between drawing and designing is further articulated by McNally:

If you cannot report on what exists. i.e. you don’t have an investigative vision of the world around you, then you can hardly be expected to report on what doesn’t exist - things that you are pulling out of your head. Objective drawing constantly informs conceptual drawing. (A88)

This represents a clear statement to establish a relationship between graphic ability and cognitive development.

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The traditional subject for drawing studies, the human model, receives some support as an appropriate focus but this is by no means unanimous. Whilst Powell suggests that designers may improve particular capabilities by sharpening their powers of observation and recording through life-drawing, McNally is more cautious about its contribution. His belief that life-drawing provokes certain ways of drawing, 'in the way that marker pens do', should be considered carefully alongside the traditional easy acceptance of such practice.

8.4 Drawing and the Exploration and Manipulation of Ideas

The role of drawing within an exploratory strategy is clearly then not limited to small patches of application. It lies at the very heart of our search for understanding. Exploration has been presented as a conglomeration of inter-related activities, some revolving around problem analysis and inquisitiveness, others around creativity or discovery and still others that are concerned with giving form and making visible the products of such exploration. The role of sketching as a means to externalise free discourse has already been discussed and it would seem that this is closely bound up with the value of, and techniques for generating and externalising, an individual's 'expression'. Howard uses this term as part of her definition of drawing as an 'external expression of an internal response'. The implications for education are considerable and it is worth highlighting here a relationship between expression and the development of young creative minds. Howard is concerned with undergraduates who intend to design for the theatre and she states:

A lot of my work with the students is to try and rid them of the preconceived thought and not to be afraid of making very instinctive responses to a piece of text or music. (A53)

It is important to make a distinction between drawing for manipulation and drawing for exploration. While the output may exhibit close similarities it is the intention of the drawer which distinguishes the two. They both appear to exploit some very delicate and ephemeral capacities of the human mind. Mention has already been made of the deliberate exploitation of ambiguity - the production of sketch drawing which is at one and the same time clear and yet flexible in its interpretation - to the benefit of the viewer and/or the drawer. Closely associated with this is the exploitation of serendipity or happy chance. This notion arose so frequently in the interviews that one is led to believe that happy chance can be conjured up or provoked at will! Perhaps the immediacy of drawing assists this process. As Matthews says, 'I think the nice thing about drawing is the spontaneity of it. You may not have even intended to do a drawing - you were just feeling around' (A83). In the same interview O'Leary talks of 'fleeting moments' during designing and encourages us to consider humour as an
important catalyst in this process of spontaneity and serendipity. Webber and Ballantine independently refer to drawing as a 'trigger' mechanism and perhaps the same illogicality that can make us laugh can supply the trigger for the creative reinterpretations necessary in creative design activity.

Such analysis is made more difficult by conflict in terms used by the interviewees. Whilst the consensus of opinion reveals drawing as largely a pleasurable activity it appears as if some success is only achieved after some discomfort involving, for example, anxiety or mental strain and this bears some similarity with Edwards identification of 'distress' in the creative act as discussed in Chapter Two. Webber develops this and refers to the influential role of anger in the production of a drawing with which she was eventually very pleased.

Another anomaly concerns the comparative value of carefully executed work and fast, transitory sketches. Although they may be intended to provide no more than a fleeting function, fast sketch drawings often display characteristics which make them very precious to the drawer and the viewer. A blend of serendipity, skill, speed, economy, pleasure, pain, anger and humour can often produce a sketch of more interest to people than the finished product whether that be a building, a domestic product, a piece of sculpture or a painting - an observation borne out by the huge popular interest in recent exhibitions of designers sketches such as Back of the Envelope held at the Victoria & Albert Museum in London in 1995-96. The roughness of a sketch would appear to be an important characteristic of some types of design drawing. A very detailed sketch at the conceptual stage may stifle creativity by limiting the interpretations possible with more ambiguous forms of drawing. This might lead to a fixing of early thoughts which might otherwise have been improved upon. Williams speaks disparagingly of his own output when he describes a certain type of drawing he does as 'appalling' but this might only be the case if such drawing were intended for purposes of communication to others. Such sketching clearly provides a valuable function for a director of a major design consultancy or he would not waste his time. This issue is developed by Margrie and Webber who deliberately exploit their drawing talents to produce different types of images, some of which are deliberately unpolished: 'Sometimes the best drawings for me are the rough sketches'. (AS3)

The distinction between exploration and development within designing is particularly ill-defined, perhaps because of the symbiotic nature of their functioning. Rarely does one get the opportunity to thoroughly complete research activity before manipulating such information in a response to various problem areas. In fact a case could be made for the importance of creatively examining the breadth of certain types of design problems, and the possible responses to them, before a systematic research process was completed. Thus drawing strategies which aim to explore problems, manipulate
information and visualise responses have no clear boundaries between them. Designing is not a linear process. Its iterative nature is well documented and this results in different requirements for drawing at any given stage of the process. To compound this issue skilled practitioners, as presented in the transcripts, are able to produce drawings which perform multiple functions. Whilst an individual designer may be exploiting drawing to creatively and personally explore an issue of concern, these same drawings may readily communicate form, detail, scale, emotion etc. Similarly much sketching activity is used to simultaneously clarify conceptual development, facilitate evaluation and provoke further generation of ideas. Any division between communication and exploration is a false one since drawing can encompass both. In reality drawing styles and purposes merge gradually into one another and reflect the personal preferences of the drawer, be they designers or other specialists exploiting drawing. There is one particular aspect of exploration which is fundamental to creative design activity. This is the ability to manipulate information in the search for a clearer understanding of the problems and the means to resolve them. Williams provides a helpful statement that illuminates a relationship between exploration and manipulation:

Perhaps in certain circumstances a quantity of sketching or scrawling is an indication of a poor or illogical process of thinking, but it can reveal a way of using a pencil as a tool to uncover ideas. Few people can actually sit down and draw something that they have imagined. It is a natural way of developing ideas. One can usually identify, by looking at somebody’s scrawlings, how hard it is for them to get any ideas. If there is a flow of ideas the sketches, the drawings seem to indicate the lucidity of thinking. (A10S)

Perhaps one of the most important relationships to establish is that which exists between drawing and modelling. Section One proposed that a capability for cognitive modelling was essential to effective design practice. Drawing was presented as one of a number of modelling tools and one with a number of unique characteristics. The notion of drawing as modelling is picked up by a number of the interviewees in this project and McNally opens the debate with an economical summary of a relationship:

Drawing is a very economical way of modelling, it is the fastest and best way of having a quick idea, a visualisation, of what is in your head and thus leads naturally into solid modelling. (A87)

It is interesting to note that designers such as Powell and Ashen, and the sculptor Bowen, refer to drawing as a ‘tool’. Such terminology aims to discourage any perception of drawing as an end product - almost to deny those values that are associated with traditional art appreciation. Yet clearly sketch drawings do provide a

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great service and do possess great value.

The manipulation of information in controlled and creative ways would seem to be a key element in a definition of design activity. As an architect, Fuller extends its application with an appeal to observe physicists manipulate information with the aid of such things as abstract patterning and formal diagrams. More importantly he provides an insight to his own manipulation of ideas during his designing of a major supermarket:

The first lot of Norwich drawings I did - there were seven A3 sheets which I just spent sort of doodling really, just playing with ideas, thinking about supermarkets, people pushing trolleys and this sort of thing. (A16)

The use of the word 'play' occurs frequently in the transcripts - and a little apologetically - as if there should be no requirement for such apparently unfocused activity. On the contrary, play can be quite a focused activity but given that it can be both it points to a human capability for a focused flexibility which is essential to creative design activity. Drawing and playing appear to possess a particularly close relationship which may reveal itself in both a formal and an informal sense. McNally refers to the former in his discussion of the teaching of drawing to three-dimensional design students:

We are teaching them about visualising ideas, about how to manipulate form, how to swing things round on paper, so they actually have the ability to see the back of an object as well as just a fixed view. (A87)

Drawing as a developmental tool receives support from other subjects, here from Ashen:

When you look at things that are successfully conceived and built you find that they have undergone a very elaborate development, each stage of which entails modification and development. A student who thinks he has got it entirely encapsulated in his head and only needs to put it down is taking a very arrogant or very ill-educated view of the role of drawing. (A7) People feel they don't need to draw, they don't need to explore the idea, but the drawing process immensely modifies what is thought of an idea. (A8)

Manipulation, then, may be interpreted as the development of an idea or ideas to extend both the quality and quantity of information available for evaluation. As Ireland puts it 'an idea in the mind begins to come through on to the paper and then it develops and as it develops you see other possibilities' (A59). Powell refers to this development via

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A major factor in the successful manipulation of information would appear to be the capability to visualise or externalise conceptual ideas through drawing and there is no dispute that a technical proficiency with drawing is very convenient. However, for many people drawing is perceived as merely an exercise of this ability to visualise. Furthermore drawing is widely viewed as simply a process of making visible complete or developed ideas but as Ashen highlights above it should be viewed as a complex symbiotic process involving visualisation, perception and evaluation. Where drawing is employed for design activity one would have to add its ability to support exploratory and developmental thought. The capacity for communication must not be overlooked since drawing is an externalisation allowing others to participate even where this is not explicitly intended. Ashen again:

"Designing is to me a most extraordinary occupation. It employs a capacity of the human animal, which we are told other animals don’t have, and this is the capacity to envisage and bring to fruition part of the visualisation." (A6)

Words are presented as insufficient on their own and unable to cope with the multiplicity of factors inherent in even the simplest idea. Speed is also suggested as an important advantage which drawing has over words for the visualisation of certain types of information. Speed is cited by Kelly in support of a design technique which exploits both drawing and photocopying for the development of artifacts to be made in silver. Occasionally visualising skills come into their own when there is a requirement for technical excellence in producing highly realistic images through skilled control of media. This may be exploited for the externalising of the designers own thought or, more interestingly, as a device to visualise (albeit in a somewhat hit and miss manner) somebody else’s conception. Aston discusses the undervalued significance of the latter with reference to planning meetings where a designer is present: ‘I always like sitting in those kind of meetings ... because you know full well the designer is going to be able to visualise very clearly’ (A18). Within the field of television graphics Aston believes that many of the designers working under him have achieved their success as a result of ‘damn good visualising skills’. The ability to visualise graphically seems to appeal across a wide spectrum of professions and activities. As a product designer, Powell finds his visualising capability in great demand in industry. An extended version of a quotation referred to earlier highlights this:

"When we go into a big company like ... (name removed) they’ve got marketing people, sales people, engineers, plastics technologists, electronics people, all these blokes. The one thing they don’t have is someone who can draw so you have got a terrific weapon. You sit down at a table at a meeting and say “oh, we..."
can do it like this', and as soon as you start to do it they say 'how do you do
that'. I would imagine even if you are a textile designer selling to a textile
company you are worth buying because they haven't got that. (A99)

Although the conceptualisation can only be Powell's there does seem to be a unique
capacity for drawing to facilitate the externalisation of someone else's ideas. As Powell
continues:

Someone will say "What about a saucepan that does this' and you say "what do
you mean, like this?" and suddenly you present them with a picture of it. (A99)

Several of those interviewed felt that design folders and sketch books were the best
indicators of design capability in young designers. Williams, for example, prefers to
by-pass laboured presentation drawings in favour of rough workbooks when
interviewing potential employees. Such rough sketching activity is viewed as personal
and creative and provides Williams with the sort of evidence he requires to make an
evaluation of someone's design capability. Seymour is equally supportive of the
importance of sketchbooks but is critical of the poor understanding of their value
displayed by students:

In education, people say "look you guys, sketchbooks are really important to get
you into college". So students panic because they haven't done a sketch book
and set to and scribble out a post-generative series of drawings. (A97)

Many of the subjects relayed a perception that students appear to misunderstand the
value and importance of drawing and sketching. Too often students believe that sketch
work undertaken after a particular design problem had been resolved would be
indistinguishable from that undertaken during the project. Their immaturity giving rise
to an inability to see a qualitative difference between drawing undertaken in parallel
with cognitive developmental processes and that merely recording stages of what has
already taken place. The value of such 'padding' was dismissed by several
interviewees and highlights important learning which needs to take place in our schools
and universities. It is not only product designers who value sketch output as a means
of determining design ability in junior designers. As a sculptor, Matthews would often
rather see background, sketched activity in preference to the finished three dimensional
sculptures. Perhaps they provide a 'window' into that personal domain highlighted by
Williams. Clearly, such drawings must communicate something about the relationship
between process, maker and product for them to arouse such professional interest and
yet the technical quality of such imagery can, on the face of it, appear quite poor. Any
graphic strategy implemented at the pace of cognitive activity will be hard pressed to
capture both concept and detail - assuming there is detail in such conceptual thought.
Marks may be quick and erratic, flitting between drawings as ideas emerge or are rejected. This combination of mental and physical activity often leads to the development of a notational graphic 'shorthand'. It may not display the conventions or codified elements of other, more developed, types of graphic communication but many subjects, concerned with two dimensional and three dimensional design, believed they had developed a unique personal graphic style. Having said this, even a cursory examination of drawing output reveals the implementation of conventions such as depth cues (for example, perspective, shading or overlapping) and symbols so that communication is facilitated. The drawings from one of the pages of a design folder by O'Leary (Fig 3.2) reveal the use of a concise graphic shorthand alongside more controlled, conventional imagery for communication.

Perhaps such personalisation of graphic output is inevitable given that it operates in parallel with analytical and synthetical mental processes which may themselves be idiosyncratic. The sketch drawing of the subjects varies enormously in quality and quantity. Some appear to trade-off communication for other developmental functions and their work is hard to 'read'. Others display a clear, meticulous approach. McNally, suggests that it is those designers involved at the fine art end of the spectrum who would have most reason to develop a less communicative, personal or internal graphic style. As for his own style he believes: 'I simply developed a way of working which suits me. It's not the same as everyone else but it influences the way in which the structure comes out in the end'. (A90)

There is no consensus regarding the notion of design discipline directing graphic style. As a fine artist Webber believes that whilst some people will draw in a precise fashion others will draw scruffily. The important thing to her is to be allowed to develop a personal style. Powell and Seymour often work together as a team and they believe they have developed a shared graphic shorthand between them. They refer to it as a high and very refined order of language suggesting a function in both the externalisation and communication of mental activity. Matthews provides a succinct conclusion to this part of the analysis by proposing links between a fast personal graphic style and the requirements of designing: 'I think as you get better at drawing you jot things down quicker so you are eliminating a lot of things quicker'. (A78)

The personal, idiosyncratic drawing seen in sketchbooks and on the backs of envelopes would appear to be a blend of experience, the requirement to explore and develop ideas, and the need to communicate. In student designers it may also reveal a capacity for creative thinking and as such is likely to remain an important indicator of design capability for admissions tutors and potential employers.

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Fig 3.2 Two pages of sketches from a folder of design work by Paul O’Leary. The project concerns the industrial design of personal weighing scales.
8.5 Drawing in Spatial Thinking and Evaluation

The relationship between drawing and thinking is central to this project. Some of the interview questions attempted to illicit responses about the way drawing skills and thinking skills were linked. The capacity for ‘three dimensional thinking’ is widely regarded as an important skill. As Powell states: ‘It certainly seems to be the case that people who can draw have an ability to think three dimensionally and revolve something in their head’. He continues:

If you’ve got a very complicated bit of moulding like, for example, the jug kettle, you can visualise not only the product but the tool that makes it. You can see where the undercuts are and you can configure it in your head. (A100)

Clearly Powell is describing a powerful manipulative capability of the human mind and one not limited to design specialists. There are many toolmakers who exhibit sophisticated three dimensional thinking as a result of their familiarity with certain artefacts but they may not be so adept with the broader spectrum of cognitive skills necessary for design thinking. Three dimensional thinking may be best developed through experience with tangible artefacts but even here drawing can support the mental skills via, for example, the formal drawing practices of the engineering disciplines or the more art based practice of observational drawing and analysis. Design thinking requires a range of capabilities for the organisation and transformation of information. Bowen illustrates these broader modelling capabilities. He suggests that many students develop conceptualising skills not through making but through drawing. Thus an important mental capacity is encouraged by the practice of drawing. If modelling can exploit the type of simultaneous cognitive processing as proposed in Chapter Two then the interviews provide some evidence for viewing a close, perhaps symbiotic, relationship between processes for manipulation, externalisation and evaluation. Even when undertaking the apparently passive activity of observational drawing some of the subjects felt that creative interpretations were difficult to suppress. Margrie, for example, talks of constructional limitations affecting the way she looks at, and draws, the bird subjects of her ceramic work. The transcripts reveal evaluation throughout the design process via iterative cycles of varying duration. Evaluation guides exploratory activity. It is present in all creative work and there is widespread agreement on the importance of drawing as a facilitator of evaluation. The volume and variety of information, even in a simple concept, may be too much to hold in the mind. Drawn images not only capture elements of a concept at a given moment in time but allow the individual to hold certain variables steady whilst manipulation or evaluation of others takes place. Williams refers to his sketching as his only means of assessing ideas - especially when they involve complex three-dimensional forms. This is developed by Bowen who views drawing as enabling the ‘testing of notions’ and the ‘anticipation of
problems'. Margrie extends the evaluative potential from the conceptual phase to the much later production of a prototype, in this case a ceramic bowl:

If you have got a drawing there, then you have got something to work from. When it gets slightly out of control you can look at a drawing and say "well, this bit is alright". (A75)

Ashen presents a more incisive analysis with his use of the term 'feedback'. He states: 'It is only through drawing that I get the feedback which tells me what is worth developing and what is not'. (A6) Playing, visualising and evaluating, then, are significant requirements in design activity. They demand the exploitation of modelling types which facilitate such delicate and fugitive mental processes.

Chapter Nine concludes this research project. It highlights the significance of the work and introduces the issues which underpin the second of the research projects involving an investigation of drawing within computer supported design teamworking via a process of graphic act analysis.
Chapter Nine

The NSEAD Project: Drawing, Sketching and Designing

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9.1 Achievement of Objectives

One of the key objectives of the project was to collect verbal evidence of the exploitation and significance of drawing from professionals engaged in commercial design activity and this has been achieved. These data facilitated an analysis and exploration of the functions and value of one particular aspect of drawing, namely, sketches and sketching for designers. The project exploited a focused interview technique to collect the views from 18 subjects who represented a wide spectrum of design practice from engineering and architecture at one extreme to the fine arts at the other. The research design was based on models of inquiry drawn from the social sciences where the subjective opinions of case studies, in certain circumstances, may be just as valid as other research techniques. The research method can prove particularly useful for illuminative studies which seek to establish the nature and extent of a human phenomenon and for this reason it was particularly relevant. The subjects were selected on the basis of their design expertise and their existing exploitation of drawing but no claim is made that they represent the whole design profession. It is proposed that their subjective views have intrinsic value and their experience of modern commercial practice can provided pointers to the exploitation of drawing today - particularly with reference to design teamworking and computer based working. The findings which emerge also highlight important requirements for design education in the future. Since the conclusion of the project a number of papers, based on the analysis presented here, have been published (see Garner 1990, 1992, 1993 & 1994).

This project provided the ideal foundation for subsequent research. Indeed it may be argued that the NSEAD/Berol bursary project provided the only logical strategy for exploratory research given the ill-defined nature of the research problem. The subsequent experimental studies were perhaps made possible as a result of the illumination of direction provided by the NSEAD work. It highlighted drawing strategies, clarified usage of terms, revealed commonalities in working practices and provided evidence for valuing drawing within design activity. The open-ended interview technique as discussed by Kidder (1981) encourages the unexpected and this turned out to be a significant advantage to the research. It allowed the conversations to address drawing functions other than those concerned with the anticipated ‘communication’. Drawing functions concerned with the manipulation and exploration of information were at least equal in importance to those for communication.

9.2 Drawing and Cognitive Processes

Drawing has been promoted as an essential aid to designerly thought but it has applications beyond the relatively narrow requirements of the design professions. Support for the importance of developing a wide-ranging graphic competence comes
from many quarters. The research highlights the value of drawing for students of many subjects - not just those who seek a career in the design professions. Drawing appears to facilitate creativity in the most fundamental sense. In the interviews presented here, Williams, for example, believes that the better one can draw, the quicker one’s ideas arise and are developed. In another interview Kelly even refers to certain chasing techniques of the craft of silversmithing as ‘drawing’ in silver. There is evidence to support the existence of an important relationship between drawing and seeing. In Section One, the role of drawing in the development of perceptual skills was noted. Hill, particularly notes: 'Drawing can and does heighten visual sensitivity. It prods the draughtsman to sharpen his observation beyond the ordinary level'. (Hill 1966)

Drawing is immensely complex in the way that it interacts with the human mind. There is considerable support for the notion that drawing may rightly be considered a language and a comparison with natural language presents some interesting parallels. Barnes, for example, discusses the use of natural language to ‘make up stories... set up hypotheses and form theories’ (Barnes 1975) and he discusses how speech can be used to construct a ‘new reality’. He refers to Vygotsky’s term ‘inner speech’ to describe that capacity of the human mind to rearrange a problem by ‘talking it over’. Barnes promotes the view that such talk clearly has more important functions than mere communication. He proposes that ‘...the importance of language... is that it makes knowledge and thought processes readily available to introspection and revision’ (Barnes 1975). The transcripts present similar capacities for drawing to support and facilitate introspection and revision along with other thought processes. The fact that the only capacity of drawing to receive serious attention has been its ability to facilitate communication has been the root of much undervaluing and lack of development of this language in education. Manipulative activity is viewed by Bruner as vital to education and he presents the capacity to ‘recode’ information as essential to normal development. He writes:

I suspect that much growth starts out by our turning around and recoding in new forms... what we have been doing or seeing, then going on to new modes of organisation with the new products that have been formed by these recodings.

He continues:

The systems by which we organise or interpret experience can be changed not only by new experiences but by representing old experiences to ourselves anew. (Bruner 1966)

Many of the interviewees reveal strategies of graphically turning around and recoding information in much the same way that Bruner describes. Drawing would appear to
offer a very suitable means of supporting the cognitive abilities highlighted by Bruner and it may have a particularly important function in design activity which demands a manipulative ability with visuo-spatial information. The comparisons with natural language are also helpful when considering the ability for drawing to support exploratory strategies. Barnes identifies a type of talk he refers to as 'exploratory talk' and which is presented as a means of groping towards a meaning. The similarity between the use of natural language in this activity and the use of drawing to support design thinking is striking: 'It is usually marked by frequent hesitations, rephrasing, false starts and changes in direction' (Barnes 1975). Barnes' observations are uncannily close to a description of those early tentative marks put down by an artist at the start of a drawing or by designers at the inception of design activity. He identifies exploration as composed of hypothetical expressions, each of which are open to modification. For Barnes the evidence is seen in such statements as 'She could have gone out' and 'He probably felt' while its counterpart may be seen as the unfinished and ambiguous doodles and tentative sketches of the designer.

That design is concerned with activity promoting association is an issue recognised by Cross:

Designing is a process of pattern synthesis rather than pattern recognition. The solution is not simply lying there among the data, like the dog among the spots in the well known puzzle: it has to be actively constructed by the designers own efforts. (Cross 1982)

The search for pattern can be seen in all manner of human endeavour such as science, music and the built environment and it pervades all levels of intellectual activity. Association of ideas and concepts may be engineered through graphic activity and the juxtaposition can be harmonious or provocative. Drawing, and more particularly sketching, may support new or hybrid conjecture via the links which are made through the mechanism of perception. Curriculum development in this field by the Open University presented chance as an important aspect in the related phenomenon of creativity. It has much in common with earlier work by DeBono on creative thinking (see, for example, DeBono 1969). Both have proposed that chance can be encouraged to contribute to creative or 'generative' thought. Sketching may be viewed as facilitating chance via the incomplete nature of its manifestation. The imagery may be idiosyncratic, unfinished or ambiguous and the subject may be poorly or incompletely understood. It may not always foster perceptive insights but sketching can create a state of mind within which the mind is receptive to suggestions. To paraphrase Pasteur, the mind can be prepared for chance. Sketching activity and sketch output may provide an important means of achieving this.
9.3 An Integrated Strategy

Whilst the transcripts may suggest some distinctions between functions of drawing activity, in practice drawing to assist manipulation, exploration and communication of ideas may have no clear boundaries. The function of clarifying ideas may be seen to have as much to do with communication as with manipulation. Similarly exploratory thought for some designers may exploit skilful representational drawing, rather than idiosyncratic sketching. There seems to be little evidence to suggest a relationship between particular graphic types and the function required at various stages throughout design activity. This may have more to do with the plurality of design thinking, the notion of, for example, thinking analytically and synthetically such that various drawing types are employed throughout the design process. This is further compounded by the often misguided notion of the existence of well defined problems and solutions within design activity. Clearly guiding problems can and must determine 'macro' issues such as overall direction but on a 'micro' level there will be numerous problems and potential resolutions which need to be confronted from the very beginning to the very end of any given design task.

The intensity of concentration that such a process might require emerges from the transcripts. It is variously described as both pleasure and pain but it is clear that many of the subjects are driven to draw as if it were an essential element of their creative functioning. Sketching for designers appears to facilitate free, spontaneous thinking necessary for the encouragement of serendipity or generation of ambiguity. It can be turned at will into a precise analytical tool to support examination or evaluation of information - including that which was previously generated. As Hill points out: 'Concepts which have but a vague presence in the mind can be shaped and examined through drawing' (Hill 1966). Much developmental thought may require models for useful perceptions to be constructed. Sketching has distinct advantages over other modelling types, not least for its speed, but also in the flexibility it offers in the hands of skilled practitioners. There is some general evidence of a notional division between creative work exploiting informal graphic techniques and more formal conventions exploited where communication is required but just as designing is iterative rather than linear so drawing strategies are compound or multifaceted rather than singular.

The appreciation of preparatory drawings such as those exploited by artists and designers has, traditionally, demonstrated a certain naivete. Drawings have been viewed as an externalisation of clear inner perceptions, as a means of communicating developed thoughts or as a record of an unfathomable and incomprehensible personal dialogue. To some extent all of these perceptions have some validity but such pigeonholing acts against a re-evaluation by the wider community. If drawing is to be recognised as an important facilitator of certain types of cognitive activity there is a need
for more research to document its particular functions. The subjects of this research illuminate the value of drawing in coming to terms with ill-defined problems - a requirement facing an increasing number of professions.

All of the research subjects appearing in this project collaborated, to a greater or lesser extent, with other individuals and groups in their professional work. Drawing would appear to make an essential contribution to this collaboration. While natural language in the form of written notes or verbal communication is often viewed as necessary to design teams the bulk of the communication often takes place via graphic output. Where meetings are convened then body language can also play a vital role in directing attention or guiding interpretation. Where these are not to be available then drawing conventions such as those of the British and European standards organisations can be exploited to overcome potential ambiguity and misunderstanding. A great many of the case studies supported the use of three dimensional models and often supplemented their own work with mock-ups, test rigs and prototypes. They ranged from full-size and life-like representations for detailed analysis of highly resolved ideas, to tiny card constructions serving only a fleeting purpose. Three dimensional models can provide information on a range of expert and user perceptions which would be difficult, if not impossible, to acquire from drawings alone. Yet drawings are often overlooked as the most versatile modelling medium of all. If modelling is the 'language' of design as Bruce Archer stated many years ago then drawing would appear to offer a significant case for being viewed as a comprehensive modelling tool:

The essential language of design is modelling... Just as the vocabulary and syntax of natural language or of scientific notation can be conveyed through spoken sounds, words on paper, semaphore signals, Morse code or electronic digits, to suit convenience, so the vocabulary and syntax of the modelling of ideas in the Design area can be conveyed through a variety of media such as drawings, diagrams, physical representations, gestures, algorithms - not to mention natural language and scientific notation. (Archer 1976)

Sketching can support mental processes to provide personal and idiosyncratic models of even the most ephemeral of concepts while a more controlled drawing may provide sufficient information for another person to offer evaluation and/or suggest development. A skilled practitioner of drawing can stimulate thought and dialogue by creating a two dimensional model of something which does not - and perhaps cannot - exist. Drawn models such as this raise the question 'which came first' the expressive, visionary capacity or the ability to convey such thought? There is anecdotal evidence from the research to suggest that the two develop in parallel through practice. When developed it would appear that graphic modelling does support simultaneous synthetical and analytical strategies. Subjects talk of producing drawings which can be 'read' on a
number of levels. A sketch drawing or, more commonly, a number of related drawings may be produced which encourage variety in interpretation. This may not facilitate successful communication but as a provocative developmental tool it may generate the creative tensions necessary to the stimulation of further conceptual activity. Whilst not everybody may reach these heights of complex graphic modelling, design education has the responsibility to understand and encourage this capacity.

The problems with such small research samples was raised in Section Two. The drawings of design subjects selected for interview in this study do not easily compare. They represent different design professions and different stages of design process. They were brought into being in a particular job for use by particular people. A comparison of the various graphic outputs are of little real value in this study and those examples which have been selected for inclusion in this report perform a limited illustrative function only. Also, creative activity is notoriously private and confidential and the research may not have been granted access to the most appropriate examples of drawing. The important data as far as this study is concerned are contained in the transcripts. The transcripts convey opinion rather than hard evidence but this is seen as having value nevertheless. The studies reveal a richness which can be both confusing and illuminating.

The pluralism of functionality, evident in design drawings and discussed above, may be one of the reasons for a neglect of research into the subject. It is a profound irony that while design education expands and design research achieves maturity, those seeking illumination of the functions of drawing are provided with little more than tips and tricks of representational drawing. It is the purpose of this programme, and particularly this project, to stimulate research into this complex field. Researchers from many disciplines, but particularly design, need to examine the role of a developed 'graphicaey' in the learning process. The academic community requires more than the 'hows' of drawing, it needs communication of the 'whys' of drawing also.

It would appear that drawing represents an important facilitator to designerly thinking. It allows ideas to be given form which in turn facilitates analysis and evaluation. Drawing acts as a record of 'unplaced' creativity which may be put to one side and referred to at some point in the future. This has the dual advantage of assisting memory mechanisms by clearing the mind of potentially confusing and disruptive detail thus enabling the manipulation of new or retained information. Evaluative strategies can also exploit drawing so as to develop and represent information and which in turn encourages new perceptions. Whilst drawing activity may at times appear random and the output ambiguous it facilitates a fast progressive focusing and the comparison of information with other modelling types. It is indeed a flexible tool. It is a phenomenon only vaguely or imperfectly understood by the general population and perhaps only

Section 3 Chapter 9 The NSEAD Project: Drawing, Sketching & Designing 114
tacitly comprehended by the design community itself. It is a sad fact that even before the full value of drawing is understood by designers the nature of design practice is changing, dramatically and irrevocably. Chapter Four examined these changes which concern the emergence and establishment of computer supported design teamworking. It is proposed here that drawing is more, rather than less, important as a consequence of these developments. Since the research programme focuses on drawing within design teamworking a sub-section concludes the chapter with possible pointers to the functions and value of sketching within design teams.

9.4 Drawing and Teamworking

As discussed above, communication is perhaps the best understood reason for using sketches in design activity. Norman McNally goes so far as to say that designers 'have a primary duty to communicate their ideas to others - that is why they are working, they have to convince others that their particular picture is valid and valuable' (A90). Most professional design activity now requires communication between numerous specialists. Roy Axe is able to identify a group of some 300 individuals who are involved in the initial development of a new motor vehicle at Rover. This is perhaps understandable given the technological nature of the product and the huge volume of production envisaged for a new car. However, the movement towards teamworking is seen in those areas traditionally viewed as the domain of the individual artist or craftsman. Patrick Ireland, as an independent illustrator, talks of an increase in dialogue within the publishing trade which exploits numerous design services. His own drawing is used to communicate with clients about concept ideas or developed proposals. O'Leary believes that the client increasingly wishes to be let into the process of design and consequently he will submit rough sketch sheets along with presentation work at client meetings. This may reflect economic pressures to reduce development time to a minimum where changes can be effected as soon as possible. John Aston at the BBC echoes this. He states that it is absolutely essential for a Producer to have a very clear understanding of what a designer is going to do for him because of limitations on costs, timescale and resources. (A10)

Television graphics illustrates as well as most disciplines the extent of teamworking today. Aston requires his design staff to collaborate, both loosely and directly, with computer graphics specialists, programmers, animators, and illustrators as well as with numerous others in the design sections. Significantly, Aston believes that drawing skills are central to successful interaction of such teams. Interaction appears to be a dynamic rather than a passive phenomenon which is why sketches may offer a very suitable medium. Both the manner of production and the objectives for sketches arising out of teamwork can vary enormously. Some may offer a clear, unambiguous proposal while others will represent very ethereal imagery. The ability of sketches to offer loose
or undefined models may facilitate multiple interpretations of information which are a distinct advantage in certain phases of creative teamworking. Pamela Howard talks of theatre design as a 'shared experience' with actors and directors and her drawing is intended to both convey intention and encourage participation: 'if you are part of a group activity sometimes your vision can be translated in a number of ways'. (A54)

One of the lesser appreciated applications of graphic ability in teamworking is that ability for individuals to act as a visualiser during team discussions. Dick Powell provides the best account of this via reference to client meetings where product concepts were being discussed. He was able to present the team with graphic models which matched the discourse of the meeting in terms of content and speed. Such models are helpful since they provide points of reference from which shared understandings can develop. Shared understandings are essential to the development of a clear and workable product design specification on which subsequent research and development will be based. The ability to consolidate team thought and to offer tangible conceptualisation for group evaluation should not be undervalued in the modern management of design. Alan Williams, who at the time of the research was a Design Director of a major design consultancy, reinforces the importance of this visualising skill. However, he believes that drawing styles have to adapt to the situation. 'In a discussion this morning we were talking about the interiors of trains and I was using the roughest of sketches - typical back of a fag packet type of drawing, but it was worth a thousand words'. (A107) Aston echoes this with his reference to his constant doodling while he is in production meetings 'helping the client focus-in'. Whether such doodling is evidence of a process of externalising internally clear conceptualisations or a means of seeking to make sense of an ill-defined situation is unclear but both would add weight to the importance of sketching.

Often such sparse and economical sketching can give rise to images which appear to capture the essence of a discussion - what Seymour terms the 'spirit' of an idea (A94). Established teams appear to exploit a form of graphic shorthand where familiarity allows partners to adopt a more economic style of sketching. Some of those subjects who were involved in design education cited student questions about the idiosyncratic (and apparently rather poor) drawing styles of certain famous designers. The consensus appeared to be that experience and long-established working relationships with others in the development teams enabled those designers to adopt a form of graphic shorthand in their sketch output. Powell and Seymour have their own shorthand style when working together and other subjects refer to named designers such as the furniture designer Magistretti (A90) to illustrate this phenomenon.

By the conclusion of the project it was clear that, for some professions, drawing and teamworking had a very close relationship. It was also clear the the NSEAD Project
would be better if it has some graphic output to supplement the analysis of the transcripts - if only to illustrate the general research context. Consequently the author invited two graduates to undertake a three hour design exercise which was recorded on video tape. This was edited down to a 30 minute tape of sketching during the exploration and development of a small domestic power tool (a mastic gun). It transpired that this video was to have an important influence on the authors future research activities and this is explained in the next chapter. Stills from the video appear as Figure 3.3. It was successful for a number of reasons. A number of copies were distributed to schools since it provided a real insight into drawing and designing; it revealed (by good fortune) a very rich and copious use of sketching in the resolution of a design task; and it presented an insight into collaborative working which did not go unnoticed. But others were to make the connection with computer based collaborative working. That is not to say that computer based working did not form part of the NSEAD project. Many subjects readily identified the advantages of computer based working to their personal activities and their professions in general but there was some concern that new working practices were marginalising the value of sketch activity in team designing.

Axe has overseen the installation of sophisticated facilities for computer based working in the design offices of Rover Group. He is adamant that bringing designers and engineers together was essential to product development and that this was only practicable via procedures based on computer based working. Nevertheless, full size models of vehicles are still produced since these offer an important means to facilitate discussion within large teams including design and engineering staff and senior management (A26). The introduction of computer aided design and computer aided manufacture (CAD-CAM) facilities and, more recently, rapid prototyping facilities have greatly reduced the size of the workforce needed for traditional modelling - the construction of full-size, three dimensional form from two dimensional information emerging from the development teams. Computer based working has allowed similar efficiencies to be made in the field of architecture. In this profession Mike Fuller identifies important advantages for the production and sharing of drawings, and the rapid communication with clients about changes to proposals (A45). Computer based working has clearly facilitated better communication within and across teams - particularly since the widespread development of the Internet which was only in its infancy when the NSEAD project was undertaken. Nevertheless, the interface perhaps still fails to offer the richness of the BBC paper tablecloth discussed by Aston which was full of sketch drawings at the end of each lunchtime (A17). This notion of supporting sketch output within computer supported design teamworking - where participants are remotely located from each other - is the central issue in Section 4.
Fig 3.3 Stills from the video of students designing made at the end of the NSEAD project.
9.5 Summary of Findings: The NSEAD Project

- Sketching provided a fast and effective means of communication within collaborative design work. Sketches facilitated communication between individuals, between design teams and with clients or other outside agents.

- Sketches and sketching supported mental imaging and the modelling of ideas in the mind.

- Sketching provided a means of externalising the results of cognitive processes as conjecture, enabling evaluation and development.

- Sketching provided a means of expression.

- Observational drawing can heighten abilities for exploring, understanding, remembering and critically judging visual information. The practice of sketching from life can promote an inquisitiveness constructive to design ability.

- Sketching was used to assist the formulation or the rephrasing of design problems. This can operate in tandem with internalised cognitive processes of an individual and/or within wider collaborative teamworking.

- Sketching supported cognitive processes associated with creativity. It potentially offered graphic ambiguity helpful to the generation of new or hybrid concepts.

- Sketches were used by designers to facilitate the transformation of ideas or the reinterpretation of existing concepts.

- Sketching enabled some individuals to rapidly generate visual form corresponding to verbal descriptions arising from group discussion. This facilitated evaluation and concept development via further verbal contributions.

- Sketches potentially embodied tangible and physical components of a design and they could embody emotional or non-verbal qualities. Sketches were able to caricature and communicate the 'spirit' of a design concept.

- Sketching was viewed as rewarding and enjoyable by interviewees.
Sketching displayed similarities with natural language in that it was used to explore ill-developed notions and to make knowledge and perceptions available for introspection, revision and recoding.

Sketches were used to confirm the quality of understanding between individuals; sketches facilitated discussion on interpretation and they assisted the construction of a shared understanding.
Section 3 Summary

The NSEAD project, via its focused interview strategy, provided insights to two central functions of sketching - the ability to support communication and the ability to support personal creative strategies. While communication via drawing was widely respected, Chapter Eight identified the importance of drawing and sketching in transformational and often internalised processes of creative design, concept exploration and idea development. Sketching has been shown to have an important role in problem-finding as well as problem-resolving. The transcripts have highlighted a capability for sketches to support an interaction between communicational and developmental strategies - both for individuals and for groups engaged in design activity.

The transcripts concur with Section 1 of this thesis which proposed that significant changes were, and are, taking place in the design professions. These changes include:

i) the rapid growth of computer based working in a wide variety of design areas;

ii) the increasing use of teams and teamworking in design; and

iii) the pressures on some areas of design practice - notably industrial design practice - to become more integrated with wider development processes via computer supported design teamworking.

This NSEAD project went some way towards illuminating the functions and values of sketches and sketching for design practice. It may also prove helpful in attempts to improve the value of sketching capability in design education. It provided a framework of understanding within which other research proposals may be generated.

The ROCOCO project and particularly the subsequent graphic act analysis by the author, which is discussed in the next section, have benefited from the NSEAD research project.
Section 4

Drawing and Designing: An Analysis of Graphic Acts
Chapter Ten

Analysis of Graphic Acts (AGA) via the ROCOCO Project

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10.1 The Inception of ROCOCO

In 1988, at the conclusion of the NSEAD project, the author organised an invitation conference at Loughborough University with the title 'Drawing and Designing'. It was intended as a means to disseminate the findings of the NSEAD project; to discuss drawing practice; to define a research agenda which potentially cut across several areas of the curriculum and to stimulate further collaborative research in the subject. Professor Michael Tovey of Coventry University and Professor Ken Baynes of Loughborough University were invited to present other keynote papers. On Saturday 28 May 1988 approximately 40 delegates comprising researchers, academics and practitioners attended the one-day conference. In the audience that day was Dr Steve Scrivener from the Department of Computer Studies at Loughborough University (now Professor Scrivener, Director of the Colour Imaging Institute at Derby University). He saw potential in the short video produced by the author and which formed part of the day's presentations. This was the edited video footage of two graduates working together to collaboratively resolve an industrial design brief devised by the author (the powered mastic gun brief). The objective of putting two design students together was so that, via collaboration, sketching activity might be stimulated and thus a useful volume of sketches would be generated over the three hours of the study. The video was intended to illuminate some of the functions attributed to drawing and sketching by the NSEAD interviewees and it was successful in doing this. However, Dr Scrivener saw the potential of recreating the study to illuminate the wider communicational requirements of pairs of subjects engaged in collaborative work - particularly design. Contemporary studies by Bly (1988), and Tang & Leifer (1988) reveal design activity to be a very appropriate context for research into computer supported collaborative working (CSCW) and the students within the Department of Design and Technology at Loughborough potentially provided relevant subjects for research studies into CSCW. A discussion of the appropriateness of design activity for research into CSCW appears in sub-section 10.2.

A short while after the conference the author was invited by Dr Scrivener to discuss a proposed major research bid with other academic staff of the Department of Computer Studies who were involved with the Computer-Human Interface research group (LUTCHI) based in that department. It transpired that a bid was devised and submitted to the Science and Engineering Research Council (SERC) for funding from the Information Engineering Directorate (IED) and the Department of Trade and Industry (DTI). Late in 1988 the team were informed that the bid for funding for research equipment and research assistants had been successful. The project was provided with funding totalling £190,000 by the DTI/SERC between 1988 and 1992 (GR/F 35814). It is comprehensively described in earlier publications (Scrivener et al, 1993; Gamer et al, 1991) and it is summarised here.
The ROCOCO project at Loughborough University was a research project in the field of CSCW. Its key aim was to specify the communication requirements of remote participants engaged in CSCW. It proposed to do this via studies of pairs of student designers. It was a very timely proposal as other CSCW studies had only recently begun in other research centres around the world (see Bly 1988; Gale 1989; and Tang & Leifer 1988). The title ROCOCO is an acronym derived from Remote Communication and CO-operation which formed the central concept of the bid. The research proposal had highlighted the need to understand and articulate current requirements in communication-rich, design teamworking situations if computer based systems for the support of collaborative work were ever to be successfully developed. It was proposed that laboratory studies would be undertaken to examine and compare collaborative design work in a traditional face-to-face setting with that in a less familiar setting involving participants located remotely from each other but linked by computer based communication technology. The ROCOCO project proposed to use industrial design as the research context and to use pairs of student designers as subjects. While, in principle, the studies could have used larger teams the pilot studies had shown that pairs exhibited all the characteristics of collaborative teamworking. The use of pairs of subjects also had advantages for the management of the studies, the recording of contributions and the analysis of data.

The ROCOCO project was multi-disciplinary with four members of academic staff - three from the Department of Computer Studies (Dr John Connolly and Tony Clarke in addition to Dr Scrivener) and one (the author) from the Department of Design and Technology at Loughborough University. These provided the expertise in computer science, human science and design necessary for the research. Additionally, Andre Schappo provided technical support. The ROCOCO project generated a large volume of data requiring a huge effort of analysis on behalf of the researchers and the three research assistants - Hilary Palmen, Michael Smyth and Shaun Clark. Typically one hour of video material could lead to 60 person/hours of analysis by staff.

A key distinguishing characteristic of the CSCW arena is its acknowledgement of the predominantly social nature of work activities. ROCOCO had a broad remit, partly due to the nature of collaborative work and partly arising as a consequence of the breadth of the research team. The project sought to investigate issues which are not part of this PhD programme such as the intrusiveness of technology; the wider effects of remoteness; the existence of preferences for certain modes of communication and the effects of impoverishing channels of communication. For the purpose of this thesis, the presentation of the original ROCOCO findings is limited. There is some description of the conduct of the ROCOCO research and a little on the findings where these relate sketching and the use of sketching in designing. While the original data and most of the publications date from the early 1990s much of Section 4 is based on more recent

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personal analysis arising from a 'revisiting' of the original project data in 1997. To avoid confusion this revisiting process is referred to as the Analysis of Graphic Acts (AGA) project. All the findings of the AGA project are the sole work of the author. Where research findings are not the sole work of the author this is declared.

The ROCOCO project defined a study, in two conditions, to examine the communicational requirements of subjects collaborating on a design task. The first condition, referred to by project members as 'Phase One' of the project focused on the qualities of face to face communication between pairs of student industrial designers. This proximal condition sought to provide a working environment which was acceptable and in many ways a familiar one to those with experience of creative professions such as design. Pairs of students shared a large flat-topped table and also shared a range of writing and drawing equipment including pens, pencils, markers and a large (A1 size) pad of plain paper as they worked on a design brief provided by the researchers. They could talk, gesture and draw with the minimum intrusion of technology and in this way Phase One provided benchmark findings for comparison with the second phase. In this second condition, known as Phase Two, each study consisted once again of a pair of student industrial designers who this time were located in separate rooms of a specially prepared research suite in the Department of Design and Technology at Loughborough University. Subjects were provided with links to each other via headset telephones, video link and a computer-mediated drawing surface. The AGA project retains this distinction between Phase One and Phase Two.

In 1988 very little software was available to enable remote sharing of a computer-mediated drawing surface. Shaun Clark, Research Assistant to the project, was responsible for producing a unique facility which came to be called ROCOCO Sketchpad. This allowed two remotely located individuals to sketch and write, via styli and tablets, onto a shared window seen simultaneously on the computer monitors of each participant. Both designers drew on the shared surface, which existed in the computer as one common file, accessible to both subjects at the same time. Changes to the shared drawings took place in real time. Each pair were provided with an industrial design brief which stipulated the problem field for the study and subjects were asked to resolve the problem as best they could in the given time. Each study in Phase One and Phase Two lasted for one hour. This duration was determined by the research team. Partly, it was restricted for practical reasons (as already stated, even one hour of video material could involve up to 60 person/hours of analyses) and the pilot study of proximal collaboration had shown that it was quite possible for two student designers to offer concept proposals to a design brief in one hour whilst maintaining what appeared to be 'normal' communication. Also, other CSCW researchers had successfully used similar time restrictions in their work.
Both Phase One and Phase Two of the ROCOCO project used volunteer student subjects drawn from the BA and BSc Design and Technology courses at Loughborough University. All subjects were second year undergraduates and most were between 19 and 21 years of age at the time of the studies. Most subjects had some familiarity with computer based working as individuals but none had experience of CSCW or other teleconferencing-type environments.

In the ROCOCO project Phase Two was much larger than Phase One because it sought to examine the nature of communication and collaboration achieved with different permutations of communication tools. That is, five studies were undertaken with all communication tools switched on ('all on'); five with no audio link ('video only'); five with no video link ('speech only') and five with no audio or video link ('drawing surface only'). In this way considerable data were generated regarding the relative use of channels of communication during team design work. Studies in both Phase One and Phase Two were recorded on video tape to facilitate study and this has proved the most useful to revisit for the purposes of the subsequent analysis of graphic activity and graphic acts. Studies in both phases produced considerable discourse and this was recorded and transcribed. The drawing pages from Phase One exist as hard copy but those from Phase Two were retained as computer files. Elapsed time within the one hour studies was used as a common reference point for the various analyses.

10.2 Design as a Context for CSCW Research

Any meaningful research in the field of CSCW requires tasks which are rich in communication. Tasks which require the exploitation of many modes of communication are likely to provide suitable environments for CSCW studies. Design activity can vary enormously, but central to it is the identification, manipulation and communication of concepts by participants. Communication within design activity has been traditionally associated with three-dimensional models, graphic representations, and written reports. However anyone with experience of designing with a colleague or within a team will be aware of the importance and subtlety of gestural and spoken communication. From early pilot studies of CSCW in the ROCOCO project (and even earlier if one considers the video presentation shown by the author at the NSEAD conference), the field of design - and more particularly 'industrial design', seemed to offer the required communication-rich environment.

Design has been termed a problem-solving activity but, as discussed in Chapter Three, it is more correctly a problem 'resolving' activity. That is to say, compromise must be sought between often conflicting requirements such as costs, production requirements, material limitations, legislation and human factors, etc. Cognitive modelling forms the means by which problems are resolved, implementing graphic and other modelling
tools and operating in parallel with communication strategies such as gesturing and
talking as well as drawing and constructing. Collaboration, together with
communication in design teams, creates shared models which have developed as a
result of joint activity. These shared models - particularly shared sketches - provide
one of the topics for discussion in this Section.

10.3 The Appropriateness of Industrial Design for the
ROCOCO Project

For CSCW research to be of value it requires a context and task of adequate complexity
and reality. The task also needs to require real collaboration as opposed to merely
putting people together to work as a group of individuals. Industrial design activity is
becoming increasingly complex involving, amongst other things, materials, costs,
production and human factors. As Chapter Four has discussed, industrial design
increasingly requires teams of specialists to come together as a consequence of the
demands for speed, breadth of knowledge and reduced financial wastage which have
become part of most programmes of new product development in manufacturing
industry. Design teams frequently adopt collaborative behaviour in order to create and
evaluate possible resolutions to an emerging task or brief. Industrial design has the
additional quality of requiring designers to work with three-dimensional concepts rather
than just the two dimensions of, say, graphic design.

The researchers were guided by a number of other factors in their decision to use
industrial design as the context for the studies. Collaboration is context-dependent, and
contemporary work (e.g. Smyth and Clarke 1990) suggests that the identification of a
creative problem (re)solving task is a necessary precondition for collaboration. The
requirements for research into collaborative behaviour and the attributes of design
activity are well matched. They were summarised in the ROCOCO final project report
thus:

i. Communication
It is to be expected that there are differences in the communication of collaborating
and non collaborating partners. Also, CSCW research requires a communication-
rich context. As a result of the complexity of their tasks, designers exploit
various modes of communication in collaborative designing which may involve
contact with numerous specialists. Such communication is very 'rich', involving
graphic, verbal and non-verbal modes, and often exploits two or more modes
simultaneously.

ii. Common Goal
Research demands that participants have a common goal. Designers work to a
given brief and this can range from a highly specified instruction to an ill-defined
requirement. With any brief the design process involves a period of problem definition and where two or more designers are involved this will involve the negotiation and definition of a common goal. In the field of industrial design the common goal (regarding the product) is established as a specification.

iii. Rewards
Motivation is a prerequisite to design activity. Without the necessary rewards a single designer, pair or team can lack the motivation to undertake the process of problem resolution. Rewards can vary enormously, for example, the pleasure of undertaking a task co-operatively may be reward in itself. This may be further subdivided into pleasure derived from drawing or from the discourse. For others, praise, promotion or remuneration may be required. The motivation for industrial designers is commonly a combination of many rewards.

iv. Distributed Responses
One of the characteristics of collaboration is the existence of distributed responses, that is, the division of activities or responses between partners working on a shared task. There is some evidence to suggest that those industrial designers working in pairs do derive a system for distributing responses in each of the graphic, verbal and non-verbal modes of communication.

v. Behaviour Norms
Norms are socially shared standards or guidelines of behaviour. Behaviour norms can be culturally specific and/or specific to the task. For industrial designers a behaviour norm might be attentiveness to the task; non-attentiveness to the drawing surface or a partner's comments constituting an infringement to an accepted convention or behaviour norm. Difficulties can arise where different conventions are in operation, for example where partners come from different cultures.

vi. Autonomous participants
Collaboration requires that each partner be autonomous, that is, they can control their contribution to the activity. For industrial designers they would each have their own means of writing and sketching although the drawing surface is commonly shared. Partners need to be free to contribute to and share drawings but, conversely, they must also be free to draw elsewhere on any shared surface if this is desired. Verbal communication can take place at any time but as with graphic communication this will require co-ordination.

vii. Co-ordination
Co-ordination is a feature of most forms of communication and requires cues to
synchronise activities. These cues can be mechanical (e.g. an alarm clock) or social. Co-ordination can be task or time related. Successful resolution of a given problem in the time allowed requires industrial designers to synchronise their activities. In some instances this is explicitly stated, for example, how long they will spend on an analysis of the brief, while at other times the more immediate social cues act to synchronise activities.

viii. Timing
Timing is pertinent to both the co-ordination of activities and the progression of the design activity. Relevant aspects include the time between responses (i.e. the latency of the collaborative response) and the time required for the response. Therefore collaborative working by designers can be affected by such things as exceptionally long (or brief) responses. Time provides a useful and consistent baseline and is therefore used for this purpose in the analysis.

(ROCOCO Project Final Report 1992)

10.4 The Design Tasks
The set tasks were intended to be achievable and yet demanding on the abilities of each subject pairing. A number of design briefs had been written for the project, each about half of one A4 page in length (see Appendix II). These were developments of industrial design tasks which had been used with other student designers in earlier years. They had been proven to offer rigorous but manageable tasks with potentially creative output. In the course of each study each subject pair completed one design task. In Phase One three briefs were used and each one appeared twice. The briefs required a concept design for one of the following: a personal digital thermometer (brief A); a portable barbecue (brief B) and a new battery operated product for the Duracell company (brief C). In Phase Two four different briefs were used in case subjects had discussed tasks with colleagues who had taken part in the Phase One studies. The Phase Two briefs were: a children's coin collecting box which encouraged children to save with a building society (brief D) which appeared twice; a flask for keeping drinks and soups hot and aimed at the school lunch market (brief E); an improved ironing board (brief F) and a garden product intended to collect fallen leaves from paths and lawns (brief G).

The briefs were devised to resemble, as far as possible, 'real' or commercial industrial design tasks in as much as they were focused on particular product contexts but also they were partly open-ended, ill-defined and demanding. Each brief required discussion and negotiation within each pair but all briefs were devised to be of an equal level of difficulty. Of course, differing interests and experiences within each pair meant that it was possible that a particular brief might suit one person's knowledge or interests.

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but the research assistants had no means of knowing of any particular expertise prior to the experiments. A number of briefs were devised and given out in a set order so that students had no means of forewarning later participants of the subject of their design task. The task selection requirements which governed the design of the briefs were:

- that completion of the task should not require any specialist knowledge beyond that which might be reasonably expected of such students
- that there was no requirement to move from the research laboratory during the study (e.g. to build any prototype or test rig, or to engage in further research)
- that each task should be, as far as possible, of equal difficulty. Ultimately this was a matter of judgement on the part of the research team.

While the overall aim of the ROCOCO project was to specify the communication requirements for computer supported collaborative working when pairs are remotely located the AGA project clearly and deliberately focuses on sketching. Chapter Eleven examines sketching via studies of subjects working proximally, that is, face-to-face as they attempt to collaboratively resolve their design brief. It provides the first substantial presentation of research undertaken as part of the revisiting process and forms Phase One of the AGA project. Chapter Twelve presents Phase Two of the AGA project. It re-examines the remote studies of the ROCOCO project and again focuses on sketching and the exploitation of graphic strategies when subject pairs are located remotely from each other and who rely on computer technology to mediate their communication. Both chapters refer to graphic act analysis as a means of comparing the production and exploitation of sketching between the two conditions.

10.5 Quality Assessment of Design Output

It was anticipated that findings concerning the use of sketching in proximal and remote collaboration would be weaker without some measure of the quality of the design work produced by each pairing in Phase One and Phase Two. For example, findings concerning less sketches being made or more use being made of particular types of graphic output would be of greater use if one were able to identify whether they resulted in a highly or poorly regarded resolution to the set brief. This was never successfully addressed in the original ROCOCO project and so as part of the revisiting of the data in 1997 the output of each pairing was evaluated to provide a score for design quality. A design quality assessment sheet was produced (a copy appears in Appendix VI). This identified six areas of assessment and required that each was graded from poor to excellent. Each grading was converted to a numerical value and the sum of all six values produced a single quality rating as a percentage.
The six areas of assessment were:

1. Level of communication. (How easy is it to understand the proposal from the design pages?).

2. Level of 'finish' apparent in the proposal (details of overall form, materials, construction, assembly etc).

3. Level of match between the requirement as described in the design brief and the proposal as seen in the design pages.

4. Level of plausibility and/or practicality in the proposal.

5. Level of inventiveness, creativity and/or innovation in the proposal.

6. Appropriateness of the proposal for the subjects age, education and experience.

The scores for each pairing are presented later (in Tables 3 and 8) together with the mean score and standard deviation for each condition. A discussion of the outcome of this design quality assessment process is provided in Chapter Eleven.

10.6 The Structure of the Presentation

The two phases which comprise this project are analysed separately. Chapter Eleven presents Phase One, the studies of proximal working, and introduces aspects of the original ROCOCO research work as well as providing detail of the more recent AGA project undertaken with ROCOCO data. Chapter Twelve presents Phase Two and similarly make reference to both ROCOCO and AGA research activities and findings. A comparison of the two phases is presented as Chapter Thirteen and this concludes with a summary of the main findings.
Chapter Eleven

The AGA Project: Studies of Face-to-Face Sketching

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11.1 Introduction to Phase One

Aim of Phase One of the ROCOCO project
To establish the communicational requirements of pairs of Design and Technology students when required to work collaboratively and proximally (face-to-face) on a given industrial design brief using traditional media (pens and paper) in a one hour study.

Aim of Phase One of the AGA project
To revisit the data generated by Phase One of the ROCOCO project; to investigate, via relevant research tools, the use of sketching by pairs of design subjects collaborating face-to-face and to identify characteristics of sketching in such designing which can be productively used for comparison with sketching activity associated with remote, collaborative designing.

Phase One of the ROCOCO project consisted of six one-hour studies each employing two undergraduate design students at approximately the mid point of their second year of the Design and Technology BA/BSc degree courses at Loughborough University. Participants were asked to turn up at the research lab with a colleague of the same gender. At the time only 10% of the student population in Design and Technology at Loughborough was female and this ratio is seen in the pairings - only one pairing (that in Study 1) was female. All subjects were assumed to have similar design experience. The subjects obviously knew each other and may or may not have worked together before. The studies took place in a purpose built research laboratory within the subjects normal building on the University campus. At the conclusion of each study one of the ROCOCO research assistants asked participants to complete a short questionnaire concerning their perceptions of their performance. Unfortunately, these data were not available during the revisiting process.

The subject pairs were seated face-to-face across a flat-topped table measuring 0.75m x 1.5m. Potentially, subjects could have been seated side-by-side but concern was expressed by researchers that such an arrangement might prohibit one partner from reaching, or even seeing, the drawing space of the other and thus adversely affecting the collaboration. Comments by participants in earlier trials indicated that they found little difficulty with the face-to-face arrangement and the resulting orientation of the output. Whilst reading a partners' text, such as annotation, upside down may have been awkward (perhaps requiring a verbal question and answer), reading the upside down drawings, which made up the majority of the output, apparently caused little difficulty. The face-to-face arrangement had advantages in that it made the whole drawing surface accessible to both partners and it assisted data collection in that the two video cameras were not obscured by the bodies of participants.
Fig 4.1 Simplified plan of the laboratory for Phase One experiments showing subjects, cameras (C) and recorders (VCR).

In Phase One subjects were provided with a pad of A1 paper placed between them on the table and they supplied their own pens, rules, curves etc. A video record of each study was made using one camera to one side of the subject pairs, and focused onto the drawing surface providing detail of the emerging graphic images and annotations along with the hand and lower arm movements of each pair, and a second camera giving a wider view of the whole scene but from the other side. This recorded the upper bodies of both subjects together with the drawing pad between them (see Figure 4.1). Figures 4.2 and 4.3 show images taken from two of the video records and provide a clearer illustration of the set up. An audio cassette tape recording of the discourse was produced as a back-up to the audio channel on the video recording.

Each subject pair were given, verbally, a standardised set of instructions by ROCOCO project staff. They were informed that they would be working to a design brief supplied by the researchers and were instructed not to erase any writing or drawings so that all work could be analysed. Neither subject was allowed to use a private drawing pad, hence all mark-making took place on the shared paper. The subjects were made aware that audio and video recordings would be made. After 45 minutes of working on the task the subjects were given a ten minute warning. After 55 minutes they were asked to finish off. Studies lasted between 55 and 58 minutes although these are referred to in the analysis, for convenience, as studies of one hour. The participants agreed to the project storing and manipulating the collected data in an electronic format. The six studies in Phase One were carried out sequentially.

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Fig 4.2 Images taken from the video records of one of the Phase One studies of the ROCOCO project
Fig 4.3 Images taken from the video records of one of the Phase One studies of the ROCOCO project

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The set tasks appeared to pose little difficulty to the six subject pairs. The questionnaire used at the end of each study revealed that subjects understood the task required of them and found the procedure straightforward. All the subjects had, to a greater or lesser extent, some experience of working in pairs and larger groups. Having watched some of the studies live and closely scrutinised them all on video one is left with the impression that the subjects were comfortable with the process. The questionnaire responses confirmed this. After a very short initial period, during which they were perhaps conscious of the recording equipment, the subject pairs chatted easily - even laughing - as they worked together. It closely resembled design situations seen in industry and education, away from laboratory studies, where designers or students work together on a design task. The ROCOCO project set-up in Phase One, including drawing on a shared drawing pad and talking together, appeared to be easy and familiar for the participants.

Each of the pairs generated between two and four A1 size sheets of sketching and writing (an example of one page is given in Figure 4.4 and copies of the total Phase One output appear in Appendix III). No pair was permitted to construct any three dimensional output during the one hour experiment although they frequently used gestures to mime the holding or using of products under consideration. The sheets contain the output of both partners ranging from the most fleeting single mark to detailed sketches and writing. Some text appears as annotation to a sketch while other text appeared as a discrete element such as a list or mathematical notation. Some images were line sketches (using a fine-line or ball point pen), others had colour applied - invariably via marker pens which were commonly exploited by the subjects in their normal coursework.

For the purpose of the AGA project a drawing (as a noun) refers to a discrete and identifiable graphic output which might have pictorial (sketch) or written elements or both. The act of drawing (as a verb) here refers to making pictorial images (sketching) and/or writing. The paper based records of drawing activity are referred to as pages or drawing sheets. Together with the video and audio records they provide the data for analysis. Photo reductions of each drawing sheet resulting from the experiments are appended to this report for information (see Appendix III) but they do not necessarily need to be viewed with the analysis.

The analysis in this chapter makes reference to several figures, which present graphically some of the data from the studies, together with tables of data. The following sub-section provides a broad-brush description of the data which emerged from Phase One and is followed in subsequent sub-sections by a closer scrutiny of particular findings. The detailed statistical analysis was undertaken with the computer based statistical program SPSS (SPSS for Windows, v.8, 22.12.97).
Fig 4.4 Examples of two pages of graphic output of one of the Phase One studies
11.2 Drawings and Sketches

The use of the terms drawing, sketch, and sketching have been explained above. To assist the analysis, each separate drawing in each study was identified by giving it a code number. This was not as difficult as it might seem. While there was some overlap between images, necessitating the marking of a ring around certain drawings in order to distinguish one from another, each drawing was largely discrete and identifiable. The first information obtained was the number of separate drawings produced in each experiment and this is shown in Table 1.

Table 1. Quantity of 'drawings' (discrete written or pictorial elements) produced on each page plus total 'drawing' production for each of the six studies in Phase One.

<table>
<thead>
<tr>
<th>Brief</th>
<th>Page 1</th>
<th>Page 2</th>
<th>Page 3</th>
<th>Page 4</th>
<th>Total No of Drawings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1 A</td>
<td>40</td>
<td>40</td>
<td>5</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Study 2 B</td>
<td>4</td>
<td>28</td>
<td>14</td>
<td>7</td>
<td>53</td>
</tr>
<tr>
<td>Study 3 A</td>
<td>59</td>
<td>29</td>
<td></td>
<td></td>
<td>88</td>
</tr>
<tr>
<td>Study 4 C</td>
<td>23</td>
<td>38</td>
<td></td>
<td></td>
<td>61</td>
</tr>
<tr>
<td>Study 5 B</td>
<td>16</td>
<td>22</td>
<td>8</td>
<td>7</td>
<td>53</td>
</tr>
<tr>
<td>Study 6 C</td>
<td>29</td>
<td>33</td>
<td></td>
<td></td>
<td>62</td>
</tr>
<tr>
<td>Combined Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>402</td>
</tr>
</tbody>
</table>

The briefs referred to as A, B, and C in Table 1 can be found in Appendix II. In Phase One a total of 402 drawings were produced giving an mean of 67 drawings per study (SD 14.2). Studies 1 and 3 produced the most drawings in total (85 and 88 respectively). Interestingly, both worked to brief A, the digital thermometer (Study 1 used the only female pairing). Study 3 produced the highest number of drawings on any one page (the first page) with 59. However, Study 2 reveals only four drawings on their first page with the majority of their output on their second page. Three studies worked on only two pages. Only Studies 2 and 5 felt it necessary to work on four pages and both of these worked to brief B, the portable barbecue.
11.3 Graphic Acts

Having given each drawing its own identifying number it was possible, by using the video recordings, to chart the history and development of each and every drawing by documenting the individual contributions which make up each drawing. These contributions have been termed Graphic Acts by the author and are based on ‘Drawing Acts’ which were defined by the ROCOCO project (see Scrivener & Palmen 1991).

Some drawings consisted of only one Graphic Act. Others consisted of several Graphic Acts over a period of time - often by both partners. Defining a Graphic Act was not straightforward. Indeed, one of the important functions of the NSEAD project presented in Section 3 was that it illuminated the complexity of drawing behaviour, its variety of exploitation and the difficulty of categorisation. If one watches someone sketching it is clear that the activity is made up from a sequence of active and reflective processes involving mark-making and evaluation. The difficulty with defining Graphic Acts concerned the level of detail required. If every occurrence of mark-making was recorded then one achieves a very fine level of detail but at the expense of a very time-consuming process. If, on the other hand, one recorded long sequences of activity as a single Graphic Act then one achieves a low level of detail, perhaps saving time and effort, but potentially losing much of the richness of drawing. For this analysis, Graphic Acts were defined as ‘continuous sketching or writing activity where pauses, interruptions etc., are less than one second in duration’. This definition allowed a subject to take their pen or pencil off the paper and then continue as part of the same train of thought. Any hesitation, pause or interrupt causing a break in graphic activity for more than one second was deemed to mark the end of that particular Graphic Act and a new one began when the individual next started drawing. There was no clear break point at one second but to have established an interrupt interval of many seconds would have meant the merging of Graphic Acts which potentially had different functions, plus a lower count of Graphic Acts for each study. Scrivener & Palmen (1991) exploit one second interrupts in their analysis of ‘Drawing Acts’ and this seems to provide an appropriate level of detail.

The analysis consisted of watching the video record of each experiment twice; the first time to record the Graphic Acts of one of the subjects and then a second time to record the Graphic Acts of their partner. This data collection process gave rise to the information presented in the bar chart shown as Figure 4.5.

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In Figure 4.5 the horizontal axis identifies the Study Number in Phase One. The six vertical bars above and below this horizontal axis refer to the total number of Graphic Acts produced by Subject A in each study and subject B in each study (identified simply by the chair in which they sat). The vertical axis presents the scale for the number of Graphic Acts. The most striking feature about Figure 4.5 is the broad similarity in the production of Graphic Acts (GAs) by the six pairs. Study 1 produced the most GAs with 279 between them and Study 2 produced the least with 187 GAs between them. There is a noticeable symmetry in some of the output. The mean GA output per subject is 110. The data allow a more detailed process of Graphic Act analysis and this is presented in the next sub-section.

11.4 Sketch Graphic Acts and Written Graphic Acts

It was immediately obvious at the outset of the analysis that the drawing pages which emerged from each study consist of two types of graphic output and the analysis of the video evidence confirmed the production of two types of Graphic Act. One type consists of acts of freehand sketching - resulting in drawings depicting elevations, sections through forms, perspective views etc. A second type resulted in writing or notation such as annotation to sketches, separate lists of words or mathematical calculation. There was a clear imbalance in favour of the former type but nevertheless it was important to distinguish between the two types - if only so that the latter type did
not cloud the findings concerning sketching. Consequently two types of Graphic Acts were defined - Sketch Graphic Acts (SGAs) and Written Graphic Acts (WGAs). Figure 4.6 re-presents the data of Figure 4.5 but this time distinguishing between WGAs, highlighted with the dark infill, and the SGAs highlighted in the lighter infill.

Fig 4.6. Bar chart showing the production and composition of Graphic Acts arising from the six studies in Phase One (Written Graphic Acts and Sketch Graphic Acts)

The mean output of WGAs was 23.5 and these accounted for only 27% of all GA activity. Once again there is much similarity between the six studies. Study 1 and Study 6 seem to show a high proportion of WGAs by one partner - perhaps as a result of an extended process of writing, listing or numerical working - and this is explored later.

Information concerning the sum total of SGAs and WGAs is less important than findings concerning the exploitation of these drawing types during design activity. Thus a time element was introduced to the data capture. This was exploited by the ROCOCO project and was repeated by the author as part of the subsequent revisiting in 1997. By counting the production of SGAs and WGAs in 5 minute time bands new data were generated concerning the use of graphic acts over the one hour of each study. This was facilitated by a small time clock running unobtrusively in the bottom corner of each video recording. Thus the analysis of each of the six studies consisted of:

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I. numbering the drawings on each sheet. The system used gave each drawing an identity number specifying the sheet and its individual drawing number. Thus drawing 3.16 referred to drawing number 16 on sheet number 3. This numbering made no attempt to convey the order in which the drawings were made.

II. capturing the WGA/SGA data. Each video was played through twice - once to identify the WGAs and SGAs of Subject A and then again to identify those of their partner. It was attempted to identify both in one viewing but it proved impossible when simultaneous Graphic Acts were produced. During this data capture process, copies of the original A1 size drawing sheets (with drawings numbered) were placed next to the video monitor so that each WGA and SGA seen on the video could be attributed to a particular drawing number. The data capture sheets were printed with time bands already established and it was relatively simple to enter the information about the graphic activity as it took place on the video - moving to a new time band every 5 minutes. A shorthand style was quickly established and this involved putting a circle round the drawing number if it was a SGA and nothing if it was a WGA. Copies of some of the data capture sheets are appended to illustrate this (see Appendix IV). While they may look messy they fulfilled their function and contain a diverse range of information.

III. Presentation. The occurrences of WGAs and SGAs were counted for each time band and displayed as a bar chart for each study. The six bar charts for Phase One are presented in Appendix V. Figure 4.7 presents all six charts on one page for the purposes of comparison. Whilst it was always intended that sketching activity, as presented via SGA output, would be the focus of the research, some of the interesting observations concern WGA production and the relationship between SGA and WGA output between subject pairs, between studies, and between conditions.

In all but one study, the production of GAs per 5 minute time band fitted within the chosen scale on the figure which had a maximum value of 18. The exception to this was Study 6 which peaked at 22 SGAs in the tenth time band (45-50 minutes). One must be cautious in drawing conclusions about such Graphic Act production which perhaps only differed by three or four acts. They can appear significant on a bar chart but in reality amount only to a few additional or a few less drawings by one or both partners. With this in mind, the following sub-section presents a closer examination of Sketch Graphic Acts and Written Graphic Acts.
Fig 4.7 AGA Phase One: A combined presentation of the Graphic Act data presented in Appendix V

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11.5 Describing the Graphic Act Data

As noted earlier, production of SGAs was much higher than that of WGAs. Out of a total number of 1321 GAs, 73% were SGAs and this, it is proposed, supports the suitability of the set tasks for examining the exploitation of sketches and sketching within design activity. While WGAs comprised just over a quarter of all GAs, their distribution was not evenly spread over the one hour periods. There was a clear emphasis on the production of WGAs at the beginning of the studies and a less clear emphasis on the production of SGAs towards the end of studies.

Studies 1, 2, 4 and 5, each displayed a significant production of WGAs by one or both partners in the first 3 time bands (15 minutes) which then ceased (apart from some single occurrences) until the final 15 minutes when WGA activity returned. This return was most notably seen in studies 1 and 2. Studies 3 and 6 offer a somewhat different profile with production of WGAs throughout each experiment. In Study 6 there was a very high production of WGAs by subject B. This study asked subjects to devise a new product for the Duracell company in order to utilise the batteries for which they are known.

The comparative levels of WGA output by partners within studies is worth comment. A significant imbalance was most dramatically seen in Study 6 but to a lesser extent this phenomenon was seen in other studies. Studies 1 and 2 revealed a clear demarcation as one partner produced the WGAs (during the first 15 minutes) while the other produced little or no WGA output - even where the discourse was even in output. Interestingly, in both these studies the partners finished the study by sharing the output of WGAs in the final 15 minutes. This 'mirroring' of output, where the production of GAs in a given time band was of a similar volume for each partner, may be an important feature of designing in pairs but it was more common in SGA output than WGA output.

Sketching activity, identified via occurrences of SGAs, dominated the output. This was a reasonable expectation given the nature of the brief and the field from which the research subjects were chosen. As undergraduates, one presumes they had been accepted for a place on a design degree course as a result of their creative and technical skills. Their coursework would have provided experiences of problem analysis and idea generation although they would not have had to work under the experimental conditions imposed by ROCOCO.

Figure 4.7 reveals an exploitation of sketching by all partners in all six studies. Sketching activity took place from the very beginning of experiments (as soon as the brief was read in some cases) and was continued until the end (up to the point when pairs were asked to stop in some cases). However, the output varied within studies and
between studies. In Studies 1, 2, 4 and 5 a distinctive profile seemed to emerge. This appeared similar in shape to a Gaussian distribution curve revealing a low level of SGAs at the outset, rising to a peak midway through a study and then tailing off towards the end. While each pair did not produce exactly the same profile there were some similarities. Also, a certain level of mirroring between partners was discerned as it was with the WGA activity. Study 4 perhaps best revealed this mirroring with each partner producing broadly similar levels of SGA activity - rising and falling together over the hour to produce very similar SGA profiles. Even the WGA profiles were similar in Study 4. Closer scrutiny of Study 4 revealed that output by each partner was closely matched in individual time bands. Between 30 and 35 minutes the production of SGAs dipped to 10 acts each and then rose to 12 each between 35 and 40 minutes. This mirroring was repeated to some extent in the subsequent two time bands (40-45 minutes and 45-50 minutes).

As with the analysis of the WGAs Study 3 and Study 6 once again stood out from the other four studies. Study 6 was unusual for its low level of sketching activity for the first 30 minutes of the study. Production of SGAs for Subject A was about one quarter of the level seen in Studies 1, 2, 4, and 5 while Subject B produced only one SGA in the first 30 minutes! However both partners attempted to make up for this after this point with Subject B producing 77% of his SGAs in the final 20 minutes of the task, peaking with 22 SGAs between 45 and 50 minutes which was the highest output of any subject in the Phase One studies. Study 3 also displayed profiles which differ from Studies 1, 2, 4 and 5. Subject B produced an erratic profile as a result of varying levels of SGA output. Subject A produced a distinctly flatter profile as a result of a broadly constant output of SGAs during the hour.

The following sub-section explores the application of written graphic activity and sketch graphic activity in the construction of shared sketches.

11.6 Shared Sketches

Within these studies of pairs of student designers, sketches consisted of single or multiple SGAs. Where they consisted of a single SGA by one partner they were often small and rapid visualisations of a basic characteristic such as a crude outline shape of an object or a representation of the size of a hole. They may have taken a very short time to produce, for example, under one second or, alternatively, they consisted of one long act, many seconds in duration. Sketches also emerged from a series of sequential SGAs (occasionally including WGAs) between which there were pauses in the sketching activity for discussion or contemplation. A further distinction of this type would be those sketches which were ‘revisited’ by the drawer, not as a continuous sequence, but in a process of returning during the course of collaborative work. These
revisits may significantly alter or develop a sketch to suit the purposes of the drawer. Considerable time may elapse between such revisits. Finally, a development of this type of sketch concerns visits (and revisits) to a sketch by the person who did not instigate it. That is, the act of developing a partners’ sketch gave rise to the term ‘shared sketch’. Thus a hierarchy of sketch types emerged:

* Sketches which consisted of a single SGA by one person

* Sketches which consisted of a consecutive sequence of SGAs (plus, perhaps, WGAs) by one person.

* Sketches which consisted of multiple single occurrences of SGA/WGAs and/or sequences of SGA/WGA activity over the period of collaborative work but which remained the work of one person.

* Sketches which were constructed from the SGAs of one person but to which their partner had made contributions via WGAs only. These were termed ‘partly shared sketches’.

* Sketches which consisted of SGAs (and perhaps WGAs) of both partners. In this thesis they are referred to as ‘shared sketches’.

For the purpose of this work, ‘shared sketches’ were those sketches where both partners contributed at least one identifiable SGA during a study. Some shared sketches consisted of several SGAs by each partner. In some cases they were transitory and a whole sequence of SGAs by both partners could be over in seconds. In other cases the sketches were revisited by both partners over a period of time - sometimes returning to earlier pages which had been worked on and put to one side. Their significance lies in the fact that shared sketches may indicate some level of shared understanding (but not necessarily agreement) which cannot be inferred from sketches which emerge from one individual. Table 2 presents the output of shared sketches in Phase One.
Table 2. Distribution of shared sketches by page and total production of shared sketches for each of the six studies in Phase One.

If shared understanding is important to collaborative work, as some authors would support, then indicators (such as shared sketches) of shared understanding are important to the evaluation of the success of such work. They are also potentially valuable to the comparative analysis between Phase One and Phase Two of this project.

Shared sketches, generally, were distributed across the pages and across the time bands in Phase One. The evenness of distribution suggested an importance throughout proximal collaborative work - perhaps shared sketches assist the establishment of agreements in problem definition or resolution. Predictably, perhaps, Study 6 presented a lower number of shared sketches than the mean. In this study, subjects worked towards a proposal for a battery powered product for the Duracell company. The majority of their SGAs were produced in the final twenty minutes of the experiment and this must have significantly affected their ability to exploit shared sketches. It may simply have been that the wording of the brief, or the requirements (explicit or implicit) in the task, worked against the production of shared sketches (particularly since Study 4 also tackled this brief and produced a similarly low count of shared sketches). Alternatively, one may put this finding down to inter-pair differences. If there exists any relationships between phenomena such as output of shared sketches, number of sketches produced and the quantity of SGAs produced by each pair then a more sophisticated analytical approach is required. As preparation for this the data generated so far was tabulated as Table 3.

<table>
<thead>
<tr>
<th>Brief</th>
<th>Page 1</th>
<th>Page 2</th>
<th>Page 3</th>
<th>Page 4</th>
<th>Total No of Shared Sketches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1</td>
<td>A</td>
<td>5</td>
<td>7</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Study 2</td>
<td>B</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Study 3</td>
<td>A</td>
<td>9</td>
<td>7</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Study 4</td>
<td>C</td>
<td>1</td>
<td>8</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Study 5</td>
<td>B</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Study 6</td>
<td>C</td>
<td>3</td>
<td>6</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Study Number</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>--------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>A Brief</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>B Design quality assessment rating (%)</td>
<td>2.5</td>
<td>2.0</td>
<td>2.4</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>C Time (Min Sec) spent on graphic activity (per subject)</td>
<td>25.05</td>
<td>26.1</td>
<td>18.54</td>
<td>20.45</td>
<td>24.50</td>
</tr>
<tr>
<td>D Number of drawings: personal and/or written (subjects A+B)</td>
<td>55</td>
<td>55</td>
<td>56</td>
<td>61</td>
<td>53</td>
</tr>
<tr>
<td>E Number of sketches (subjects A+B)</td>
<td>71</td>
<td>51</td>
<td>56</td>
<td>56</td>
<td>44</td>
</tr>
<tr>
<td>F Number of shared sketches (subjects A+B)</td>
<td>14</td>
<td>13</td>
<td>16</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>G Number of SGAs (per subject)</td>
<td>120</td>
<td>94</td>
<td>76</td>
<td>97</td>
<td>120</td>
</tr>
<tr>
<td>H Number of SGAs (subjects A+B)</td>
<td>214</td>
<td>163</td>
<td>167</td>
<td>189</td>
<td>185</td>
</tr>
<tr>
<td>I Mean SGAs per sketch</td>
<td>3.10</td>
<td>3.19</td>
<td>2.98</td>
<td>3.43</td>
<td>4.30</td>
</tr>
<tr>
<td>J % of SGAs in 3 most visited sketches (per subject)</td>
<td>21%</td>
<td>22%</td>
<td>31%</td>
<td>39%</td>
<td>45%</td>
</tr>
<tr>
<td>K Number of SGAs committed to sketches</td>
<td>88</td>
<td>80</td>
<td>106</td>
<td>70</td>
<td>99</td>
</tr>
<tr>
<td>L SGAs committed to sketches as a % of each part’s SGA output</td>
<td>41%</td>
<td>49%</td>
<td>63%</td>
<td>37%</td>
<td>54%</td>
</tr>
<tr>
<td>M Sketches comprising 2 or less SGAs &amp; as a % of each part’s sketch output</td>
<td>55</td>
<td>38</td>
<td>45</td>
<td>41</td>
<td>28</td>
</tr>
<tr>
<td>N Sketches comprising 3 or more SGAs &amp; as a % of each part’s sketch output</td>
<td>71% (71%)</td>
<td>70% (70%)</td>
<td>60% (60%)</td>
<td>73% (73%)</td>
<td>64% (64%)</td>
</tr>
</tbody>
</table>

Table 3. The AGA data table relating to Phase One

Section 4 Chapter 11 The AGA Project: Studies of Face-to-Face Sketching 150
Table 3 facilitated a number of useful comparisons within Phase One and these are discussed in sub-section 11.7. These data are also central in the comparison between the two phases. The vertical columns refer to the six studies in Phase One - the numbers corresponding to those referred to earlier - plus the row title, identification letter and Mean / Standard Deviation column. A short explanation of each row follows:

<table>
<thead>
<tr>
<th>Row</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>This presents the identification letter for the brief used by each pairing (three briefs were used, each appearing twice). The briefs appear in Appendix II.</td>
</tr>
<tr>
<td>B</td>
<td>The design quality of the output of each pair was assessed against six criteria resulting in a design quality mark expressed as a percentage figure. A copy of the quality assessment sheet appears as Appendix VI.</td>
</tr>
<tr>
<td>C</td>
<td>The time each subject spent engaged in graphic activity in minutes and seconds (subject A above subject B).</td>
</tr>
<tr>
<td>D</td>
<td>The sum of the two times shown in Row C giving the total time engaged in graphic activity for each pairing (out of a maximum possible of 120 minutes).</td>
</tr>
<tr>
<td>E</td>
<td>The number of drawings (pictorial and written) produced. This row reproduces the information provided in the final column of Table 1.</td>
</tr>
<tr>
<td>F</td>
<td>The number of sketches (pictorial) produced by each pairing (this number includes sketches produced by each individual and those sketches arising jointly from both partners, that is, shared sketches).</td>
</tr>
<tr>
<td>G</td>
<td>The number of shared sketches produced by each pairing.</td>
</tr>
<tr>
<td>H</td>
<td>The number of SGAs produced by each individual subject (subject A above subject B).</td>
</tr>
<tr>
<td>I</td>
<td>The sum of the two figures given in Row H. This gives the total SGA output for each pairing.</td>
</tr>
<tr>
<td>J</td>
<td>The number of SGAs per sketch for each pairing (Row I divided by Row F).</td>
</tr>
<tr>
<td>K</td>
<td>The percentage of SGAs appearing in the three most visited sketches for each individual (subject A above subject B).</td>
</tr>
</tbody>
</table>
Row L  The number of SGAs committed to shared sketches for each pairing.

Row M  Row L expressed as a percentage of total SGA production for each pairing.

Row N  The number of sketches comprising three or less SGAs (N1) and presented as a percentage of total sketch production by each pairing (N2).

11.7 Discussion of Table 3

11.7.1 Design Quality Assessment

An assessment of the design quality of the output of pairings was undertaken by the author and, as a check on the procedure, a second assessor was enlisted. Both the author and second assessor have many years experience of assessing undergraduate design work. The two assessments used the same criteria but were conducted entirely separately. While the two assessments did not provide identical scores there was sufficient agreement for the author to have confidence in the assessment schedule and the assessment procedure. With regard to Phase One pairings, the author achieved a design quality mean score of 67% with the second assessor achieving 81%. The rank ordering was substantially the same. The checking procedure served its purpose and it was decided to use the authors own assessment data (rather than use a mean of the two sets of data) and this is what appears in Row B. It can be seen that Studies 2 and 3 achieved high scores for design quality (79% each) while Studies 4 and 5 achieved the lowest scores (53% each).

11.7.2 The Distribution of SGAs Across Sketches

Another phenomenon was observable in the data which might have proved significant in the comparisons of the studies of Phase One with those of Phase Two. This concerned the distribution of SGAs across drawings. The six bar charts presented in Figure 4.7 highlight the varying production of SGAs over the one hour of each study. However, the charts do not specify how many individual sketches this activity was divided amongst. It is possible that a high level of SGAs for any one subject was entirely contained in one sketch - developing and building it up over several time bands. Alternatively, the same high level of output may have been directed towards the production of numerous but less developed sketches. Knowledge of the distribution of SGA activity was likely to be important in analysing the significance of shared sketch activity and it potentially provided a useful means to substantiate conclusions about the exploitation of sketching in collaborative working.

As previously discussed, the output of each study consisted of between two and four A1 size sheets of paper. Each drawing was given its own identifying number, for
example 2.23 specified drawing number 23 on sheet number 2. These numbers were recorded on the AGA data capture sheets for every instance of pictorial and written activity in each of the time bands. Although these data appear in chronological order it was a simple task to produce a list of sketch numbers and then to allocate each SGA to one of the sketches. Copies of the data capture sheets appear in Appendix IV. Table 4 presents the number of sketches worked on by each individual and some of the findings were revealing.

The high level of SGA activity in the studies was not distributed evenly across sketches. Some sketches appeared to be significant or 'favoured' in that they received a larger proportion of SGAs and a greater number of 'visits'. In Study 5, for example, Subject A produced sketch output on each page. He produced 120 SGAs over the hour (see Row H, Table 3) and worked on 31 sketches (see Table 4) - a nominal SGA-to-sketch ratio of 4:1. However when one examined the distribution of SGAs it was apparent that two sketches were significant to the subject - drawing number 3.3 consisted of 21 SGAs while drawing number 4.1 consisted of 24 SGAs (see Appendix IV). This imbalance is seen in other studies. In Study 4, Subject A produced 97 SGAs and worked on 32 sketches - approximately a 3:1 SGA-to-sketch ratio. However, this subject used 26 of their SGAs in drawing number 2.22.

Although sketches received an average of 3.29 visits in Phase One overall, Row J of Table 3 reveals a small range (2.79 visits in Study 6 to 4.30 visits in Study 5, SD 0.5). When the number of SGAs in the three most visited sketches for each participant were added together they comprised a significant part of all SGA activity. Row K of Table 3 reveals that for each individual 32% (mean) of all SGAs were applied to just three sketches. The distribution of SGAs across sketches is further illuminated by Row N2 of Table 3. This reveals that, on average, 74% of all sketches (shared and individual) contained three or less SGAs (SD 5.6). Such fast, transitory, sketches, which might be described as 'thumbnail sketches', would appear to be an important element of graphic activity in such designing.

Favoured sketches were often also shared sketches but were not exclusively or equally so. In the cases presented above the partners added only a handful of SGAs to the combined totals. There is no evidence to suggest that favoured or shared sketches were worked on by both partners to an equal extent. Row L of Table 3 presents the number of SGAs committed to shared sketches for each pair while Row M presents this information as a percentage of total SGA activity for each pair. 46% of SGAs were committed to shared sketches which is a considerable proportion of sketching activity. The range includes 63% in Study 3 to 30% in Study 6.
Table 4. Number of sketches worked on by each participant in the six Phase One studies.

When one examined the relative numbers of sketches worked on within each pairing there was an unexpected similarity which is presented in Table 4. In Study 1 both subjects worked on over 40 sketches each. Many of these were the same sketches in that they were 'shared' but it was useful to be able to observe the differences between participants. In Study 6 the subjects matched each other's output again with 24 and 28 sketches worked on respectively. With the exception of Study 3 there was a close similarity within pairs of the numbers of sketches worked on. There are a number of possible reasons for this: it is possible that individuals, by their actions and output, influenced their partner to work on more or less sketches or perhaps there existed a desire not to 'stand out' in the studies. Certainly there was an element of mirroring in output within each page and not just in the cumulative total. In general, where there was an imbalance between partners concerning the number of sketches worked on, this imbalance was maintained throughout the study. It could be that totals of 'sketches worked on' (as presented in Table 4) were falsely inflated by single visits to sketches by one or both partners. In the studies the dominant producer of sketches did not fluctuate from one partner to another.
Where subjects chose to extend their work beyond two pages there was a dramatic
decrease in the production of sketches but a subsequent increase in the average time
spent on them. Studies 1, 2 and 5 chose to use more than two pages. Note that in the
case of Study 2 (see Table 4) nearly half of the total SGA output was generated after the
second page (which was concluded just after halfway through the study) and this was
distributed over 24 sketches (the first two pages accounted for the remaining 40
sketches). Study 5 was even more dramatic. Half of the SGA output occurred in the
second half of the study (on pages 3 and 4) and yet this generated only 16 sketches
(30% of the total output of sketches). This would be consistent with a process of
developing and detailing established images which presented a high level of agreed
information. This analysis is returned to in Chapter Thirteen in a comparison with the
work undertaken as Phase Two which occupies the next chapter.

The first part of the AGA research study, undertaken via a process of revisiting the
video and graphic output generated by Phase One of the ROCOCO project, was
successful. It has provided new data concerning the use of sketching between pairs of
subjects engaged in face-to-face design activity. Phase Two of the ROCOCO project
sought to replicate the design activity of Phase One with the important difference that
subject pairs were located remotely from each other and linked by computer mediated
technology. This Phase provided the AGA project with raw data on which a similar
examination of graphic activity could be undertaken. Its conduct is described in the
next chapter.

11.8 Summary of Findings from Phase One of the AGA
Project

- A mean of 67 drawings per study (SD 15.6) was produced (Row E, Table 3) of
  which 54 (mean) were pictorial ‘sketch’ drawings (Row F, Table 3). Of these,
  12 (mean) were shared sketches (Row G, Table 3).

- The mean time spent sketching by pairings was 35 minutes 21 seconds (out of
  120 minutes) (Row D, Table 3).

- Between 2 and 4 pages were used by each pairing (Table 1).

- An assessment of the design quality of the outputs from Phase One pairings
  produced a mean score of 67% (Row B, Table 3).

- 1321 Graphic Acts took place in total producing a mean Graphic Acts output per
  subject of 110 (Figure 4.5).
Sketch Graphic Acts (SGAs) accounted for 73% of all Graphic Acts. The remainder were Written Graphic Acts (WGAs) (Figure 4.6).

Various 'profiles' of the distribution of Graphic Acts were discernible in the data such as a 'mirroring' of output between partners (Figure 4.7).

46% of SGAs were committed to shared sketches (Row M, Table 3).

SGA activity was not distributed evenly across sketches. On average, 32% of SGAs were to be found in the three most visited sketches of each participant (Row K, Table 3).

74% of all sketches (shared and individual) contained three or less SGAs (Row N2, Table 3). These were defined as fast, transitory, 'thumbnail' sketches, and may be important in collaborative design activity.
Chapter Twelve

The AGA Project: Studies of Sketching Activity where Partners are Remotely Located

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12.1 Introduction to, and Description of, Phase Two

Aim of Phase Two of the ROCOCO project:
To investigate the communicational requirements of pairs of Design and Technology students when required to work collaboratively but located remotely from each other on a given industrial design brief in a one-hour study. Subject pairs will be linked by computer-based tools.

Aim of Phase Two of the AGA project:
To revisit the data generated by Phase Two of the ROCOCO project and to investigate, via relevant research tools, the use of sketching by pairs of design subjects collaborating remotely via computer-based tools. Ultimately, a comparative analysis of Phase One and Phase Two is sought.

Phase One of the ROCOCO project concerned a study of communication between student designers working proximally on a shared design problem. Phase Two sought to analyse communication between student designers collaborating in real time but in different locations. In Phase Two, communication between subjects was mediated electronically, and pen and paper were replaced by a computer-based shared drawing surface. While the original ROCOCO project led to speculation and hypotheses concerning the significance of a variety of verbal and non-verbal communication in collaborative design work, this thesis will continue with its focus on the investigation of the function of sketching between pairs of subjects engaged in an industrial design task that is, the Analysis of Graphic Acts (AGA) project.

Phase Two of the ROCOCO project again drew its subjects from the second year of the Design and Technology BA and BSc degree programme at Loughborough University. The studies took place in the same purpose-built laboratories at Loughborough University as Phase One but this time each pair were separated, with individuals given a separate room and provided with their own computer workstation. Test pairs were matched for gender and were assumed to have similar design experience. New design briefs were selected from the same batch used in Phase One and these appear in Appendix II. Task selection requirements were the same as for Phase One and once again in the course of each one-hour study each subject pair completed one design task.

Whereas Phase One required only six pairs of subjects, Phase Two of the ROCOCO project was intended to test improvements to various modes of communication and thus it required many more pairs. Four conditions were identified and, ideally, six studies of pairs would have been undertaken in each of the conditions (requiring 48 participants). Unfortunately, there were not sufficient student volunteers in the year group and only five studies were possible in each of the four conditions. It would have
been possible to use first or third year students but this would have had its own disadvantages in a comparative analysis. It was deemed acceptable to compare the six studies of Phase One with the five studies in each condition of Phase Two. Thus twenty studies took place involving twenty pairs of subjects over a period of two months in 1990. The four conditions were:

i. 'All-on' condition. This full configuration allowed participants to verbally communicate with each other via a lightweight headset telephone. It also provided a video picture of the partner's head and upper body via a second monitor located to one side of the main computer screen. A clever use of camera, mirrored glass and seating position allowed each subject the impression that they had eye contact with their partner when they looked into the VideoTunnel as it came to be known. Thirdly, each partner shared an electronic drawing surface (appearing as a large window on the main monitor) onto which they could simultaneously draw via A4 size graphics tablets and pens located on the desk in front of the monitor (see Fig 4.8). A more detailed description of the equipment is provided in sub-section 12.2. The All-on condition was designed to emulate as closely as possible the face-to-face workspace of Phase One. The research team anticipated that this condition would be the most useful, facilitating an analysis of the effects of remoteness and electronic mediation on design activity.

ii. 'Video-off' condition. This was as above but with the video channel removed. This took away the picture of the partner and thus it denied the use of eye contact and any communication via gesture.

iii. 'Speech-off' condition. As 'All-on' but with the headset phone removed. Thus no verbal communication was possible between partners.

iv. 'Video and Speech-off' condition. This was also known as the 'Drawing-surface-only' condition. In this condition the shared drawing surface was the only means by which subjects could communicate.

For the purpose of this thesis the analysis will focus on a comparison of the five 'All-on' or full configuration studies of Phase Two with the six studies of Phase One. As far as the sketching analysis is concerned very little useful information emerged from the second, third and fourth conditions. These present some useful findings concerning the wider communicational requirements in such situations and they highlight interesting relationships between modes of communication but they do not form part of the AGA project.
12.2 Conduct of and Equipment for Phase Two

In the five studies for each condition the two subjects were welcomed to the laboratory and located in their separate rooms. They were introduced to the technology configuration they were to use and were encouraged to familiarise themselves with the facilities via informal remote communication with their partner for approximately 20 minutes. Figure 4.8 provides a simplified illustration of the seating arrangement and the layout of the equipment in the two laboratory rooms. When all communication channels were switched on subjects were able to hear and speak to their partner to share an electronic drawing surface which was displayed on a monitor screen (Monitor a1 and Monitor b1) and to see a video image of their partner on a second monitor (Ma2 and Mb2) via the VideoTunnel arrangement.

![Fig 4.8 Simplified illustration of the seating arrangement and layout of equipment (the ROCOCO Station) used in Phase Two studies.](image)

At the start of each study each pair received a verbal briefing plus a written copy of the design brief which they were to attempt to resolve together. The instruction to all participating pairs was similar to that used in Phase One, as was the timescale and operation of each study. At the conclusion of each study the subjects were debriefed and asked to complete a questionnaire regarding the task and use of equipment (data not available to the AGA project). A video record (and audio record where relevant) was made of each participant during the studies. Graphic output was captured on video (see Figs 4.9 and 4.10) and was retained as a series of computer files.
Fig 4.9 Stills from one of the Phase Two video records showing Subject A (top picture) and Subject B (lower picture) seated at their respective ROCOCO stations. The participants were in separate but adjoining rooms.
Fig 4.10 Stills from another of the Phase Two video records. A multiple video image was available (bottom picture) which included the facial image available to each subject via the Video Tunnel.
**ROCOCO Station** was the name given to the collaboration workstation developed for the purposes of the ROCOCO project. Two such workstations were linked in order to run remote sessions. When using the link each subject sat at their own **ROCOCO Station**. A shared drawing surface was displayed on a 21" computer monitor in front of each of them. For the research subjects, all interaction with the computer was via a digitiser and stylus. To one side of each computer workstation was the **VideoTunnel** video link containing a video monitor and camera. Displayed on this monitor was a head and shoulders image of the remote partner. The **VideoTunnel** arrangement developed by Michael Smith, Research Assistant to the project, followed an earlier model proposed by Randall Smith *et al.* at Xerox 'ARC (see Smith 1989). It used half silvered glass and mirrors to allow the illusion of eye contact over the video link. Subjects wore lightweight telephone headsets in order to hear each other and communicate verbally. Figures 4.9 and 4.10 show photographic images taken from the video recorders.

A central element of the **ROCOCO Station** was the **ROCOCO Sketchpad** shared drawing surface which was developed by Shaun Clarke, Research Assistant to the ROCOCO project. The Sketchpad allowed two or more designers, sitting at different computer workstations, to share a drawing surface and to engage in many of the interactions available in face-to-face working. It took the form of a large shared window which was displayed on each participant's workstation screen. Subjects were able to simultaneously sketch and write in the window using a limited selection of pen colours and pen thicknesses selected from a menu bar displayed at the top of the window. All marks made on the surface were made visible to both users instantly. As well as being able to make marks, a participant was able to direct remote colleagues attention to a particular area on the surface via a continuously displayed 'telepointer'. The menu bar also allowed subjects to select a blank page to work on or return to a previous page of output but they did have to agree on which page they were to both work. The functionality of **ROCOCO Sketchpad** was defined by the drawing behaviour observed in the face-to-face studies of Phase One. In these studies it was found that, despite having a large variety of drawing implements available, the subjects used only a few pen types. Additionally, rulers and templates were very rarely used. Hence, only four pen colours and three pen thicknesses were provided for users of the Sketchpad.

Research into shared drawing activity and shared drawing surfaces, including some ground-breaking work at Xerox PARC, has identified four requirements for systems which attempt to support shared sketching and drawing activity (Tang & Leifer 1988; Bly & Minneman 1990). These are:

i. Marks and gestures should be made visible to all participants without significant
delay.

ii. Rapid switching between sketching, writing and gesturing should be possible.

iii. Users should be able to mark, erase and gesture in the same space simultaneously.

iv. Familiar mechanisms for drawing space activity should be maintained.

The *ROCOCO Sketchpad* was designed to satisfy these requirements. A guiding principle was that the sketchpad should appear as familiar as pen-and-paper in order to minimise the effects of such a computer-mediated facility on sketching activity. It was designed to be directly usable; to allow its users to make use of their existing skills; to require the learning of few new skills; and to involve the minimal loss of skills. (ROCOCO 1992)

12.3 Data Capture and an Introduction to the Analysis

It is worth dwelling on the manner of the data capture used by the author in the recent process of revisiting the raw material before proceeding to the analysis and the findings. In Phase One each study had generated their respective original or 'master' drawing sheets. These A1 size sheets of paper made analysis relatively easy since it was possible to provide each drawing with its own identifying number and then to watch the video record with these drawing sheets in order to catalogue graphic activity for both partners in each study. In Phase Two the graphic output existed as computer files and this posed different problems. Technical problems with reconstructing and displaying the large shared drawing files necessitated constructing paper-based models of the original sheets which could be used in the analysis. The procedure for constructing these models was as follows:

i. Assembling the video collection - Each study had generated a VHS video record of Subject A and a separate VHS video record of Subject B. Each video revealed the upper body of one subject sitting at their workstation plus it revealed their view of their monitor screen displaying the shared graphic surface (as shown in Figs 4.9 and 4.10).

ii. Modelling the video data - By watching the video recording of each participant in turn it was possible to re-draw an approximate graphic model of the output as A4 size sheets. It was most accurate to do this sheet by sheet, that is, to reconstruct the output of Subject A for sheet 1 then to add the output for Subject 2 for sheet 1 before moving to sheets 2, 3 and 4 etc. Since each video presented the images being constructed, the drawer's hand plus the verbal communication taking place between each pair it was relatively easy to construct a suitable model of each original drawing page.
iii. Labelling - Having produced these A4 models it was then possible to label each discrete drawing by giving each its own identification number.

iv. Data capture - It was then necessary to watch each video again only this time to match each and every 'graphic act' to a particular numbered drawing and to record the data on data capture sheets (copies appear in Appendix IV). This technique provided models of the pictorial (sketch) and written output. While the models differed in detail from the original computer based images they fulfilled their function in that it was possible to identify discrete drawings and to number them. This facilitated the counting and attributing of all Written Graphic Acts (WGAs) and Sketch Graphic Acts (SGAs) as in Phase One. These models also facilitated the further investigation of the shared sketch phenomenon which emerged from Phase One.

Having closely observed the video record of each of the studies and been present for some of them it was clear that the subjects found Phase Two a more difficult situation than that presented in Phase One. While subjects would have known their partner the context of computer supported collaborative working was new to all subjects. There was time to gain some familiarity with the equipment prior to the studies but it was not feasible within the given research resources to enable all participants to become expert. Rococo Station had been designed for the novice user and yet its intrusiveness was observable, most noticeably at the beginning of the experiments. However, subjects relaxed into the collaborative sessions as they became more familiar with the equipment and with the laboratory setting. The design briefs were selected from the same collection used in Phase One and these were, as far as possible, matched for their level of difficulty. While no Phase One subjects took part in Phase Two the Phase One briefs were not reused in case Phase One subjects had discussed their work with other students who were to become subjects for Phase Two. The selected briefs, which appear in Appendix II, concern the design of a novelty coin collector or savings bank for children (brief D); an ironing board (brief E); a garden leaf collector (brief F) and a childrens’ flask for hot liquids (brief G). In these five studies brief D appeared twice (Study 1 and Study 5). All briefs necessitated negotiation between the subjects in order to determine the requirement(s) and the process of resolution.

12.4 Graphic Activity and Graphic Acts in Phase Two

As in Phase One the graphic marks - this time made via the graphics tablets and appearing on the monitor screens - varied from the most fleeting of touches to very detailed images. It was apparent that less written activity had taken place compared with Phase One and this is discussed later. Subjects had used the full range of pen sizes and colours available although not in every study.
Each pair generated between three and five sheets of electronic 'pages' of drawing and writing activity collectively referred to as 'graphic activity'. Two of the studies generated five pages; two generated four pages; and one generated three pages. The first significant observation concerned the number of separate 'drawings' produced in each study. Here, as in Phase One, 'drawings' refer to instances of written text as well as pictorial imagery. Table 5 presents the combined number of drawings produced on each page by participants plus the total number of drawings generated in each study. The corresponding figure for Phase One would be Table 1. In each case in Phase Two the first page contained the greatest number of drawings with a steady decline in drawing quantity in subsequent pages. In the two studies which exploited a fifth page then this page reversed this decline with a small upturn in numbers of drawings produced.

<table>
<thead>
<tr>
<th></th>
<th>Page 1</th>
<th>Page 2</th>
<th>Page 3</th>
<th>Page 4</th>
<th>Page 5</th>
<th>Total No of Drawings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1</td>
<td>16</td>
<td>11</td>
<td>8</td>
<td>1</td>
<td>6</td>
<td>42</td>
</tr>
<tr>
<td>Study 2</td>
<td>20</td>
<td>18</td>
<td>7</td>
<td>5</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Study 3</td>
<td>20</td>
<td>15</td>
<td>1</td>
<td>6</td>
<td>8</td>
<td>50</td>
</tr>
<tr>
<td>Study 4</td>
<td>17</td>
<td>16</td>
<td>11</td>
<td>5</td>
<td></td>
<td>49</td>
</tr>
<tr>
<td>Study 5</td>
<td>29</td>
<td>10</td>
<td>5</td>
<td></td>
<td></td>
<td>44</td>
</tr>
<tr>
<td>Combined Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>235</td>
</tr>
</tbody>
</table>

Table 5. Quantity of drawings produced on each page plus total drawing production for each of the five studies in Phase Two.

It was possible to increase the detail of the investigation as was undertaken in Phase One. There was merit in identifying the number of individual Graphic Acts (GAs) since this helped in understanding the functioning of drawing in this context. As in Phase One any drawing might consist of a single GA - a single mark or fleeting impression - or it might be built up from several GAs put down by one or both partners. Once again the definition of a GA was that used in Phase One, that is,
This data collection process gave rise to the information presented in the bar charts shown as Figures 4.11 and 4.12. These are directly comparable with the bar charts shown in Figures 4.5 and 4.6 of Phase One since they use a common scale. The horizontal axis identifies the number of each of the five pairs of subjects (also known as the Study Number) which make up Phase Two. The five bars above this horizontal axis refer to the total number of Graphic Acts produced by Subject A in each pair (identified simply as those sitting in Room A); the five bars below the horizontal axis refer to the total number of Graphic Acts produced by Subject B in each pair (those sitting in Room B). The vertical axis presents the scale for the number of Graphic Acts.

Fig 4.11 Bar chart showing the production of Graphic Acts for the five pairs of subjects in Phase Two

There was some similarity in the production of Graphic Acts (GAs) across the five pairs. Study 4 produced the most GAs with 238 in total and Study 2 produced the least with 181 GAs. While there were differences in production of GAs between partners (particularly in Study 2 and Study 3) there was a certain constancy in overall GA output between studies. In total, 1095 Graphic Acts were produced which gave a mean GA output per subject of 109.5.
In Figure 4.12 the GA activity is divided by composition as well as by subject. It reveals the very low production of Written Graphic Acts (WGAs) when compared to the output of Sketch Graphic Acts (SGAs). Out of 1095 Graphic Acts only 89 (8%) were WGAs.

![Bar chart showing the production and composition of Graphic Acts for the five pairs of subjects in Phase Two (Written Graphic Acts & Sketch Graphic Acts).](image)

**12.5 The WGA and SGA Data of Phase Two**

When the totals of WGA and SGA activity are displayed as distributed across their respective time bands, in exactly the same fashion as was done for Phase One, then five new charts are derived which present the profiles for WGA and SGA activity for each of the five studies in Phase Two. These are presented collectively as Figure 13 and the full-size charts are available in Appendix V. As with Phase One, sketching activity, identified via occurrences of SGAs, dominated the output and, consequently, the analysis of WGA activity in Phase Two occupies only a small part of this thesis.

WGAs comprised 8% of total GA production and their distribution was not evenly spread over the one hour periods. As in Phase One there was a clear emphasis on the production of WGAs at the beginning of studies and to a lesser extent an emphasis on the production of WGAs towards the end of studies (Studies 3 and 5 displayed a
Fig 4.13 AGA Phase Two: A combined presentation of the Graphic Act data presented in Appendix V
production of WGAs in their early time bands: Study I displayed a production of WGAs in the final two time bands). WGA activity was low in all studies around the middle time bands. There did appear to be a certain 'mirroring' in WGA output between partners which was observed in some of the Phase One studies.

The total output of SGAs across all five studies was 1006 which produced a mean SGA output per subject of just over 100. Sketching activity was apparent in all time bands from the very beginning of studies to the final time bands but as with the studies of Phase One the output of SGAs varied over the hour. Distinctive SGA profiles may be perceived in bar charts shown as Figure 13. Study I presented one type of profile where the SGA output of both subjects rose (mostly) steadily to the mid point of the experiment and then both tailed away to the end. Closer scrutiny revealed potentially important differences between the pair - while Subject A presented a smooth profile, Subject B presented a more erratic profile involving clear dips in SGA activity. This second type of profile was, to a greater or lesser extent, apparent in all studies and revealed a fluctuating output of SGAs by one or both partners during the hour. A third 'opposing' profile feature was apparent but less easy to distinguish. It appeared occasionally where the output of SGAs for one partner rose and fell in the opposite direction to their partner. That is, as one partner increased (or was permitted to increase) their output of SGAs so the output of SGAs of the other partner decreased. Take Study 4 as an illustration of this. SGA output was broadly similar for both subjects in the first time band (0-5 minutes). In the subsequent two time bands the output of SGAs by Subject A fell with a corresponding increase by Subject B. In the fifth and sixth time bands (20-25 minutes and 25-30 minutes) the situation was reversed with increased SGA output by Subject A and a corresponding decrease by Subject B. The situation was reversed again after this for a short time with both subjects finally completing the task with a generally even generation of SGAs. This phenomenon was also seen clearly in Study 2 and to a lesser extent in Studies 3 and 5. Interestingly, in Study 1, Partner B appeared to exhibit the erratic profile of turn-taking while their partner exhibited the evenly curved profile of output discussed above. This would not seem to be a factor associated with the design task. Study 1 and Study 5 set their respective pairs the same task - to design a novelty coin collector which would encourage children to save with a building society (brief D).

A fourth type of output profile displayed the erratic peaks and troughs discussed above but also displayed a clear mirroring between partners. Such a hybrid profile was not common but was seen at certain points in some of the studies. Study 5 displayed most clearly a situation where both subjects increased or decreased their output of SGAs together and they did this in nearly every time band - the third time band displayed a joint decrease; the fourth a joint increase; the fifth a joint decrease and the sixth a joint increase. This was also seen towards the end of Study 3 where output of SGAs rose
for both subjects although not at the same levels or at the same velocity. Subject B of this Study (Study 3) provided a unique profile for Phase Two. This profile displayed a steeply rising output of SGAs from the mid point to the end of the experiment and therefore produced an output curve which resembled that of Study 6 of Phase One. In both studies the subjects had been keen to complete, before the deadline, a proposal which had floundered a little at about the mid point of the study. In Study 6 (Phase One) the SGA output of both partners rose whereas in Study 3 (Phase Two) Subject A dramatically cut back SGAs in response to the output of Subject B.

12.6 Shared Sketches

During all studies both subjects produced sketches as a result of their SGA activity. The range of the number of sketches produced by pairings varied from 42 to 50 with a mean of 47 (SD 3.7). Some of these sketches consisted of a single SGA but most of them were developed from a series of SGAs by one or both partners. A distinction was made between sketches which were revisited by the original maker only and those which were revisited by both partners. It was stated that where sketches contain at least one SGA from each partner they were deemed to be 'shared' sketches. Shared sketches were presented as possible indicators of some level of shared understanding (but not necessarily agreement) which may not be inferred from sketches which emerged from one individual. Furthermore, it was proposed, shared understanding may be significant in collaborative design work and, therefore, indicators of shared understanding were important to the evaluation of the success of such work. Table 6 tabulates the shared sketch output of Phase Two.

<table>
<thead>
<tr>
<th>Study</th>
<th>Page 1</th>
<th>Page 2</th>
<th>Page 3</th>
<th>Page 4</th>
<th>Page 5</th>
<th>Total shared sketches per study pair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>Study 2</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>2</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Study 3</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>Study 4</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>Study 5</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td></td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>79</td>
</tr>
</tbody>
</table>

Table 6. Distribution of shared sketches by page and total production of shared sketches for each of the five studies in Phase Two.

Section 4 Chapter 12 The AGA Project: Sketching and Remote Partners
In Phase Two the mean output of shared sketches was 16 (SD 3.1) with the range being 20 to 12. It is interesting to note the relatively even distribution of shared sketches across the five studies of Phase Two and across the pages of each study (Table 6) particularly if one notes the steep decline in the quantity of 'drawings' produced on each page (Table 5). This is returned to in the comparative analysis in Chapter Thirteen.

Table 7 presents the number of sketches (shared and individual) worked on by each pair and each individual within each pair (the totals do not correspond to Row F in Table 8 because Table 7 counted a sketch twice where both partners worked on it). With a mean of 45 sketches per study, and a SD of only 3.6 (see Row F, Table 8) Phase Two displayed a consistency in sketch output.

<table>
<thead>
<tr>
<th>Study 1</th>
<th>Page 1</th>
<th>Page 2</th>
<th>Page 3</th>
<th>Page 4</th>
<th>Page 5</th>
<th>Number of sketches worked on per subject</th>
<th>Combined total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>4</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>25</td>
<td>53</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>3</td>
<td>28</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Page 1</th>
<th>Page 2</th>
<th>Page 3</th>
<th>Page 4</th>
<th>Page 5</th>
<th>Number of sketches worked on per subject</th>
<th>Combined total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9</td>
<td>11</td>
<td>6</td>
<td>4</td>
<td></td>
<td>30</td>
<td>71</td>
</tr>
<tr>
<td>B</td>
<td>17</td>
<td>14</td>
<td>7</td>
<td>3</td>
<td></td>
<td>41</td>
<td></td>
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<th>Page 2</th>
<th>Page 3</th>
<th>Page 4</th>
<th>Page 5</th>
<th>Number of sketches worked on per subject</th>
<th>Combined total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12</td>
<td>13</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>33</td>
<td>60</td>
</tr>
<tr>
<td>B</td>
<td>8</td>
<td>7</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>27</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Study 4</th>
<th>Page 1</th>
<th>Page 2</th>
<th>Page 3</th>
<th>Page 4</th>
<th>Page 5</th>
<th>Number of sketches worked on per subject</th>
<th>Combined total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9</td>
<td>10</td>
<td>6</td>
<td>3</td>
<td></td>
<td>28</td>
<td>59</td>
</tr>
<tr>
<td>B</td>
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<td>10</td>
<td>7</td>
<td>2</td>
<td></td>
<td>31</td>
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</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Study 5</th>
<th>Page 1</th>
<th>Page 2</th>
<th>Page 3</th>
<th>Page 4</th>
<th>Page 5</th>
<th>Number of sketches worked on per subject</th>
<th>Combined total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>18</td>
<td>9</td>
<td>4</td>
<td></td>
<td></td>
<td>31</td>
<td>59</td>
</tr>
<tr>
<td>B</td>
<td>17</td>
<td></td>
<td>7</td>
<td>4</td>
<td></td>
<td>28</td>
<td></td>
</tr>
</tbody>
</table>

Table 7. Number of sketches worked on by subject pairs in each of the five studies in Phase Two.

12.7 The Distribution of SGAs Across Sketches

Chapter Eleven discussed the distribution of SGAs across the sketch output of Phase One and there was good reason to do the same for Phase Two. It was proposed earlier that knowledge of the distribution of SGA activity, together with knowledge of the use and significance of shared sketch activity, was likely to be relevant to developing conclusions about the exploitation of sketches and sketching in collaborative working.
As with Phase One the individual data charts (Figure 4.13 & Appendix V) highlighted the varying production of SGAs over the one hour of each experiment in Phase Two. However, they do not specify how many individual sketches this activity was divided amongst. Again, it was possible that a high level of SGAs for any one subject was entirely focused onto one sketch or, alternatively, they might have been directed towards the production of numerous, but less developed, sketches. The following observations were based on secondary data sheets constructed as part of the AGA project (examples appear in Appendix IV).

Subsequent to producing the graphic models of the computer based design pages each drawing on each page was given its own identifying number. As in Phase One, these drawing numbers allowed the author to attribute every Graphic Act to a particular drawing and, by mapping them onto five-minute timebands, to document the broad chronological order of their construction.

The secondary data sheets allowed the compilation of a more detailed data table (Table 8) which revealed, amongst other things, the exploitation of SGAs in the five studies in Phase Two. As with Phase One some explanation is presented with the Table itself, followed by discussion. The comparative analysis of the detailed data tables of SGA activity for Phase One (Table 3) and Phase Two (Table 8) is presented in Chapter Thirteen.

Row A: This presents the identification letter for the brief used by each pairing (four briefs were used, only brief D appeared twice). The full briefs appear in Appendix II.

Row B: The design quality of the output of each pair was assessed against six criteria resulting in a design quality mark expressed as a percentage figure. A copy of the quality assessment sheet appears as Appendix VI.

Row C: The time each subject spent engaged in graphic activity in minutes and seconds (subject A above subject B).

Row D: The sum of the two times shown in Row C giving the total time engaged in graphic activity for each pairing (out of a maximum possible of 120 minutes).

Row E: The number of drawings (sketch and written) produced. This row reproduces the information provided in the final column of Table 5.
<table>
<thead>
<tr>
<th></th>
<th>Study Number</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>A</td>
<td>Brief</td>
<td>D</td>
</tr>
<tr>
<td>B</td>
<td>Design quality assessment rating (%)</td>
<td>30.05</td>
</tr>
<tr>
<td>C</td>
<td>Time (Min/Sec) spent in graphic activity (per subject)</td>
<td>27.25</td>
</tr>
<tr>
<td>D</td>
<td>Time (Min/Sec) spent in graphic activity (subjects A+B)</td>
<td>57.30</td>
</tr>
<tr>
<td>E</td>
<td>Number of drawings: pictorial and/or written (subjects A+B)</td>
<td>42</td>
</tr>
<tr>
<td>F</td>
<td>Number of sketches (subjects A+B)</td>
<td>42</td>
</tr>
<tr>
<td>G</td>
<td>Number of shared sketches (subjects A+B)</td>
<td>16</td>
</tr>
<tr>
<td>H</td>
<td>Number of SGAs (per subject)</td>
<td>113</td>
</tr>
<tr>
<td>I</td>
<td>Number of SGAs (subjects A+B)</td>
<td>204</td>
</tr>
<tr>
<td>J</td>
<td>Mean SGAs per sketch</td>
<td>4.85</td>
</tr>
<tr>
<td>K</td>
<td>% of SGAs in most visited sketches (per subject)</td>
<td>33%</td>
</tr>
<tr>
<td>L</td>
<td>Number of SGAs committed to shared sketches</td>
<td>147</td>
</tr>
<tr>
<td>M</td>
<td>SGAs committed to shared sketches as % of each pair’s SGA output</td>
<td>72%</td>
</tr>
<tr>
<td>N1</td>
<td>Sketches comprising 3 or less SGAs as a % of each pair’s sketch output</td>
<td>23</td>
</tr>
<tr>
<td>N2</td>
<td></td>
<td>(53%)</td>
</tr>
</tbody>
</table>

Table 8. AGA Data table relating to Phase Two
Row F  The number of sketches produced by each pairing (this number includes sketches produced by each individual and those sketches arising jointly from both partners, that is, shared sketches).

Row G  The number of shared sketches produced by each pairing.

Row H  The number of SGAs produced by each individual subject (subject A above subject B).

Row I  The sum of the two figures given in Row H. This gives the total SGA output for each pairing.

Row J  The number of SGAs per sketch for each pairing (Row I divided by Row F).

Row K  The percentage of SGAs appearing in the three most visited drawings for each individual (subject A above subject B).

Row L  The number of SGAs committed to shared sketches for each pairing.

Row M  Row L expressed as a percentage of total SGA production for each pairing.

Row N  The number of sketches comprising three or less SGAs (N1) and presented as a percentage of total sketch production by each pairing (N2).

12.8 Discussion of Table 8

As with Phase One there was an assessment of the design quality of each pairs' proposal. This was undertaken exactly as for Phase One. Studies 2 and 3 achieved the highest scores for design quality (63% each); Studies 4 and 5 achieved 53% each and Study 1 achieved 43%.

With reference to the output of pairs, a mean of 47 (SD 3.7) drawings was produced with 45 (mean, SD 3.5) of these being pictorial sketches. Row J of Table 8 reveals a mean production of 4.5 (SD 0.6) SGAs per sketch. For individuals (and, in some cases, pairs), some drawings appear to have been significant or 'favoured' in that they received a larger proportion of drawing acts via a larger number of 'visits'. Row K presents, for all ten subjects, the number of SGAs committed to an individuals' 'top three' sketches as a percentage of their total SGA output. This was, potentially, an important measure since it may highlight the relative use of revisiting sketches (as opposed to starting new sketches) between the phases. In Study 1 for example, Partner
A produced 113 SGAs (from Row H, Table 8), distributed over 25 sketches (Table 7). This provided a SGA-to-sketch ratio of 4.5:1. However 17 of these SGAs were applied to drawing number 2.7 (data sheets, Appendix V). In fact 33% (Row K, Table 8) of his SGA output was contained in three favoured sketches one of which was number 2.7 - the others being number 5.1 and number 4.1. Partner B in the same study produced 91 SGAs and worked on 25 sketches. His top three most visited sketches (measured by volume of SGAs) were the same as his partner (drawings 2.7, 5.1 and 4.1) but this time they account for 28% of his SGA output. In this study the three most visited sketches were also shared sketches (in fact, they were the same sketches) but this was not the case in all studies. The data on the pairs in Study 2 and Study 5 revealed that their six most visited sketches were also shared sketches but each subject exhibited unique permutations of favoured sketches.

Rows L and M of Table 8 presents the figures for SGAs committed to shared sketches (Row M as a percentage of the combined total SGA production for that pair). A mean of 61% (SD 14.4) of all SGAs were committed to shared sketches and this is returned to in the comparative analysis in the next chapter.

The distribution of SGAs across sketches is further illuminated by Row N of Table 8. In Phase Two a mean of 51% (SD 10.8) of sketches was produced with three or less SGAs (a mean of 22.5 sketches with three or less SGAs out of a mean production of 44.6 sketches). These sketches with so few SGAs may be considered the equivalent of 'thumbnail' sketches in that they are fast and transitory. They too provided a potentially useful means of comparing sketch activity between the two phases. Phase One was quite rich in this type of sketch output.

The next chapter presents the comparative analysis of Phase One and Phase Two. It speculates on the reasons behind the differences seen in the graphic act research and it discusses the research issues of sketching in computer supported design teamworking.

12.9 Summary of Findings from Phase Two of the AGA Project

- A mean of 47 drawings per study (SD 3.7) was produced (Row E, Table 8) of which a mean of 45 were pictorial 'sketches' (Row F, Table 8). Of these, 16 were 'shared sketches' (Row G, Table 8).

- The mean time spent drawing by pairings was 53 minutes 17 seconds (out of 120 minutes) (Row D, Table 8).

- Between 3 and 5 'pages' were used by each pairing (Table 5).
An assessment of the design quality of the outputs from Phase Two pairings produced a mean score of 55% (Row B, Table 8).

1095 Graphic Acts took place in total producing a mean Graphic Act output per subject of 109.5 (Fig 4.11).

Sketch Graphic Acts (SGAs) accounted for 92% of all Graphic Acts. The remainder were Written Graphic Acts (WGAs) (Fig 4.12).

Various 'profiles' of the distribution of Graphic Acts were discernible in the data such as a 'mirroring' of output between partners (Fig 4.13).

61% of SGAs were committed to shared sketches (Row M, Table 8).

SGA activity was not distributed evenly across sketch output. On average, 29% of SGAs were to be found in the three most visited drawings of each participant (Row K, Table 8).

51% of all sketches (shared and individual) contained three or less SGAs (Row N2, Table 8). These were defined as fast, transitory, 'thumbnail' sketches, and may be important in collaborative design activity.
Chapter Thirteen

The AGA Project: Comparisons, Discussion and Findings

13.1 Introduction to the Statistical Comparisons 179

13.1.1 The t-test 180

13.1.2 The Mann-Whitney test 180

13.2 Indicators of Significance 181

13.3 Further Discussion and Speculation 187

13.4 Overall Findings of the AGA Project 189
13.1 Introduction to the Statistical Comparisons

Having completed the research described in Chapters Eleven and Twelve a comparison of the data which emerged from the two phases was undertaken. The data presented in Table 3 and Table 8 was central to this comparative analysis. For convenience, Table 3 and Table 8 have been reproduced in this Chapter as Table 9 (on one fold-out page). It was anticipated that some of the comparisons could prove to be insignificant but at the outset of the AGA project they seemed to offer plausible avenues of inquiry.

Table 3 and Table 8 presented the mean value for each row plus the standard deviation (SD) indicating dispersion. An initial objective was to obtain a statistical inference from the small samples which would indicate, with some measure of confidence, a characteristic of the populations concerned. As Siegel & Castellan (1988) confirm: 'A common problem for statistical inference is to determine, in terms of a probability, whether observed differences between two samples signify that the populations sampled are themselves really different'. There are clearly differences between the findings of Phase One and Phase Two but could these be due merely to chance or a sampling error? The statistical analysis for this project set out to investigate whether Phase One and Phase Two were indeed from two different populations.

Any test for significance had to acknowledge the particular characteristics of this research - not least that it used very small samples (six studies in Phase One and five studies in Phase Two). While the subjects were all drawn from the same student group they were all independent samples, that is, the Phase one and Phase Two studies were not formally matched or paired in any other way. Also, the type of data produced by the studies influenced the selection of statistical techniques. Parametric tests, for example, assume a normal data distribution, indicated graphically by a bell-shaped distribution curve, and are really only appropriate for nominal data such as event counts or timings which do not rely on judgements in the data capture process. Ordinal data require an alternative approach - one not based on the means and standard deviations of the parametric tests. These so-called 'non-parametric' tests also measure the significance of a difference but do so without reference to the sample distribution or the population distribution.

This statistical analysis involved two common and well respected tests - the t-test and the Mann-Whitney test. Modern computing technology allows a wide range of statistical tests to be performed on research data and the almost instantaneous responses of computer based statistical programs such as SPSS can potentially lead the unwary to perform far too many tests on any data obtained. With this in mind both the t-test and the Mann-Whitney test were selectively used via SPSS (SPSS for Windows, V8).
13.1.1 Statistical Analysis (t-test)

The t-test is a widely accepted statistical test of significance which uses the standard error of the differences between means. It is used where samples are independent as opposed to related or matched. It is particularly appropriate to small sample studies in that it does not place reliance on the standard deviation of a sample reflecting the standard deviation of the population. The t-test uses the standard error of the differences between means and thus it can reveal significance even where small samples are used. It assumes a much flatter 'normal' distribution curve than related tests (such as the z-test which uses standard deviation in its calculation) and thus the t-test requires greater differences between samples in order to show up as significant. In fact, the smaller the samples the greater the differences need to be. This was viewed as a very positive quality for this research. Any relevant element which showed up as significant under the t-test was worthy of further exploration.

13.1.2 Statistical Analysis (Mann-Whitney test)

In recent years non-parametric statistical techniques have emerged as robust and reliable tools for data analysis. Authors such as Siegal & Castellan, referred to above, have highlighted the weakness of parametric techniques in that they can require a restrictive framework of assumptions concerning the nature of the populations from which any observations or data are drawn. Findings from parametric statistical techniques should normally contain qualifiers and this has hindered the ability of such techniques to present clear and useful findings. Siegel & Castellan have promoted non-parametric statistical techniques for a wide range of applications where stringent assumptions about the population are unnecessary or unhelpful. The Mann-Whitney test has been promoted by them as an appropriate non-parametric test for studies which consist of a two-sample case (in this case, proximal and remote conditions) and where individual samples are independent (that is, they are not matched or paired). The test consists, basically, of a sophisticated rank-ordering system with values attributed according to position in the rank order. As with the t-test described above, the Mann-Whitney test is used to determine whether two independent groups have been drawn from the same population. Siegel & Castellan view the Mann-Whitney test as one of the most powerful of the non-parametric tests and present it as an alternative to the parametric t-test. The Mann-Whitney test was viewed as particularly appropriate for this research since it can operate with small sample studies and it can accommodate groups of unequal size (in this case comparing the six studies of Phase One with the five studies of Phase Two).

It was most convenient to run both tests on all data and to highlight, in the subsequent analysis, which of the two tests was the most relevant for the type of data concerned. This had the added advantage of facilitating a comparison of the significance indicators.
of two very different tests undertaken on the same data. A full comparison of significance for each element of the data is provided and this is included in the fold-out Table 9.

The author was mindful of Type I errors (accepting a difference as significant when it was not) and Type II errors (failing to recognise the significance of a difference) with the particular data of this project. With this in mind the significance levels were set at the 5% level (significant); the 1% level (highly significant) and the 0.1% level (very highly significant). The indications of significance are discussed in the following subsection.

13.2 Indicators of Significance

While some elements of Table 9 were central to the research there were other elements which were not relevant to the analysis. Row C, for example, presents the timings for each individual being engaged in graphic activity. The A and B pairings could have been in any order and therefore no significance was sought. Similarly with Row H which presents the total number of Sketch Graphic Acts (SGAs) per subject, and Row K which presents for each individual the percentage of SGA production found in their three most visited sketches. These rows do not form part of this analysis.

For the remainder of the rows it can be seen from Table 9 there was a certain consistency between tests - even with the exercising of caution regarding the appropriateness of the parametric t-test on some of the data. Following accepted statistical practice the level, not merely the occurrence, of significance is indicated in Table 9 using the following scale:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>no significance.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>approaching (significance).</td>
<td></td>
</tr>
<tr>
<td>*</td>
<td>significant.</td>
<td>Significance at the 5% level (p&lt;0.05)</td>
</tr>
<tr>
<td>**</td>
<td>highly significant.</td>
<td>Significance at the 1% level (p&lt;0.01)</td>
</tr>
<tr>
<td>***</td>
<td>very highly significant.</td>
<td>Significance at the 0.1% level (p&lt;0.001)</td>
</tr>
</tbody>
</table>
CONTAINS PULLOUT
<table>
<thead>
<tr>
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<tr>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Brief</td>
<td>Design quality assessment rating (%)</td>
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Table 9 A combined presentation of Table 3 and Table 8 plus indicators of significant differences between the two sets of data.

Section 4 Chapter 13 AGA: Comparisons, Discussion & Findings

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<table>
<thead>
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<th>Level of Significance</th>
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** KEY **

NS = no significance.
A = approaching (significance).
* = significant.
Significance at the 5% level (p<0.05)
** = highly significant.
Significance at the 1% level (p<0.01)
*** = very highly significant
Significance at the 0.1% level (p<0.001)
Chapter Eleven discussed the generation of these ratings which were presented as percentage scores. In Phase Two the mean assessment mark was 22% lower than that of Phase One (67% for Phase One and 55% for Phase Two) and this appeared promising regarding finding a significant difference. A two-tailed test was relevant for this since it was not predicted whether the design quality would go up or down. However, both tests revealed ‘no significance’ (NS).

This element presented, for each study, the combined time of subject A and subject B being engaged in graphic activity. It was a crude measure of the amount of graphic activity being undertaken by each pairing in each condition. Both the t-test and the Mann-Whitney test were appropriate and both resulted in an indication of significance. A two-tailed test was again relevant here since it was not predicted whether the time engaged in graphic activity would go up or down between conditions. The t-test found a highly significant difference (p<0.01) while the Mann-Whitney test found a significant difference (p<0.05).

The mean time for each condition was surprisingly different - 35 minutes 21 seconds in Phase One and 53 minutes 17 seconds in Phase Two (note that these means derive from combined timings for both partners and therefore have a maximum of 120 minutes). Phase Two participants spent 51% more time making graphic acts than their Phase One counterparts. For some reason remote partners needed to make greater use of their stylus than would be the case if they were proximal and using traditional pen and paper. It might be that sketching was being used to maintain a common focus of attention on the monitor screens, that is, it was used as a ‘pointing’ or ‘attention-getting’ device. In Phase One the video records revealed substantial periods of non-sketching activity as partners talked or, in some cases, remained in silent and private thought and this partly accounted for the lower mean time. When sketching was resumed by one partner in proximal collaboration this was immediately obvious to the other via the physical act it requires. In the remote condition such body and arm movements were probably less apparent and the more frequent use of sketching may have been an attempt to compensate for this. There was potentially a greater sense of isolation in the remote setting and it would be understandable if sketching was being used to establish and maintain a constant contact with the remote partner.

Row E Number of drawings (pictorial and written) produced by each paring
Row E presents the total number of drawings produced by each pair in each condition. In this row ‘drawings’ included discrete written or numerical entities such as lists as well as pictorial sketch imagery. There was a 30% decrease in overall drawing production when subject pairs worked in the computer supported remote condition (the
mean dropped from 67 drawings to 47 drawings). Both the t-test and the Mann-Whitney test were usable and as the direction of change was not anticipated a two-tailed test was appropriate. The t-test identified this as significant (p<0.05) and the Mann-Whitney test as highly significant (p<0.01). The reduction in output of drawings in Phase Two might have been to do with subjects' lack of familiarity with computer based tools - for example the use of stylus and graphics tablet as input devices. Alternatively it might have been related to differences in available drawing space - the proximal condition used A1 size paper while the remote condition limited participants to a 21" monitor (both conditions, however, provided access to as many 'pages' as subjects required). It might also indicate a preference to work-up existing sketches, lists, etc, rather than instigate new ones. The production of less drawings is not necessarily important. It may be that subjects were working more efficiently, especially when one considers that no significant difference was found in the design quality assessment.

Row F Number of sketches produced by each paring
It was anticipated that not only might the numbers of drawings change between the two conditions but that the type of drawings might change also. Row F concerns the number of sketches (perspective, isometric etc) produced by each pairing. In spite of producing 30% fewer drawings, remote pairings produced only 17% fewer sketches and the t-test and the Mann-Whitney test did not reveal a significant difference. The remote pairings were making much less use of written and numerical 'drawings' such as calculation, lists and word-based mind-maps. Phase One resulted in a total of 402 such drawings of which 321 were sketches (ratio 1.25 to 1) whereas in Phase Two a total of 235 drawings were produced of which 223 were sketches (ratio 1.05 to 1).

Row G Number of shared sketches produced per paring
Row G presents the count for the number of shared sketches produced by each pairing. The alternative hypothesis under examination was that the number of shared sketches would be significantly different between the two conditions. Only the t-test gave any indication and this was only 'approaching' significance (p=0.061). In spite of producing a 17% lower mean number of sketches in the remote condition, the mean number of shared sketches was 31% higher. It has already been proposed that pairs preferred to work-up existing sketches in the remote setting rather than begin new ones - perhaps because in each sketch existed a certain level of shared understanding. Thus in the remote condition idea development and design progression seemed to proceed via a process of 'modification' of ideas rather than 'innovation'. While shared sketches may be very important to the dynamics of collaboration an over-reliance on shared sketches may have a suppressive effect on the progression of a design where they are used in place of new sketches. However, the lack of significant difference between output qualities of the two conditions would not support this.
Row I  *Number of Sketch Graphic Acts per pairing*
It was anticipated that the use of Sketch Graphic Acts (SGAs) might differ between conditions. Therefore the research carefully defined and logged these acts and the counts for each pairing appear as Row I. Both the t-test and the Mann-Whitney test were relevant. Although there was a 16% greater production of SGAs in Phase Two neither test finds any significance. Perhaps remote pairs found the construction of SGAs as easy and convenient to produce as those who worked face-to-face and used traditional media of pen and paper.

Row J  *Mean SGAs per sketch*
While no significant difference was found between the two conditions in respect to Row F (number of sketches produced per pairing) and Row I (number of SGAs produced per pairing), Row J sought a deeper examination of the relationship between the two. It presents for each study the mean number of SGAs per sketch. There were 37% more SGAs per sketch in Phase Two (mean 3.29, SD 0.5 in Phase One and mean 4.52, SD 0.6 in Phase Two). Both the Mann-Whitney test and the t-test (two-tailed) revealed a highly significant difference between the two conditions (p<0.01).

However, the mean number of SGAs per sketch can be a potentially misleading statistic. SGAs were not spread evenly over all sketches as Row K (percentage of SGAs in the three most visited sketches for each subject) and Row N2 (sketches comprising three or less SGAs as a percentage of a pairs total sketch production) confirm. Nevertheless, given this highly significant difference between the conditions one may be confident in identifying a change in use of sketching when subjects were placed in the computer mediated setting. They spent more time engaged in sketching activity; they made fewer sketches overall; they made fewer sketches but more shared sketches and each sketch contained a greater number of Sketch Graphic Acts.

Row K  *Percentage of SGAs in the three most visited sketches*
There was close similarity in the overall means for both conditions. However, no test was applied to this data. It was interesting to note the very close mirroring of percentages between partners in most proximal and remote studies. There is no obvious reason behind this. Perhaps a synergy within each pairing acted to regulate and unify the application of SGAs. Alternatively, one partner may have dominated the other resulting in conformity. Be that as it may, such close similarity between partners within pairings, between pairings, and between conditions was noteworthy.

Row L  *SGAs committed to shared sketches (per pairing)*
Row G presented the finding that the mean number of shared sketches was 31% higher in Phase Two but, possibly due to variance, this was only approaching significance. Of interest here was the number of SGAs committed to shared sketches for each pairing. The data revealed that 52% more SGA were committed to shared sketches in
Phase Two (a mean of 80 SGAs, SD 25, for Phase One; a mean of 122 SGAs, SD 29.2, for Phase Two). While this was shown to be significant via the t-test (p<0.05) and approaching significance via the Mann-Whitney test (p<0.055) these data must be approached with caution. In comparing the counts of SGAs committed to shared sketches between the two conditions the differences in both the volume of SGAs produced (Row I) and the number of shared sketches produced should be taken into account. Far more useful was the data presented in Row M which presents the number of SGAs committed to shared sketches as a percentage of total SGA production for each pair (plus the mean and standard deviation for each condition).

Row M  SGAs committed to shared sketches as a percentage of total SGA production for each pair
Phase Two saw a 32% increase in the mean SGAs committed to shared sketches where this was expressed as a proportion of total SGA output (Phase One 46%, SD 12; Phase Two 61%, SD 14.4). However, neither test revealed any statistical significance in the difference between the two conditions. Nevertheless, shared sketching is worth noting for possible future investigation.

Row N1 Numbers of sketches comprising three or less SGAs
The video analysis allowed a clear and unambiguous counting of sketches which received three visits or less (by either partner or both). Both the t-test and the Mann-Whitney test were appropriate and both found a highly significant difference between the two conditions (p<0.01) in a two-tailed test. The difference between the means reveals a Phase Two decrease of 42% in the production of sketches with three or less SGAs (Phase One 40%, SD 9.8; Phase Two 23%, SD 4.8). This finding may be largely distorted by differences in volume of sketch production and therefore Row N2 sought a more useful measure by correcting for this.

Row N2 Number of sketches comprising three or less SGAs expressed as a percentage of sketch production for each pairing
Row N2 takes into account the differing production of sketches between the two conditions and it reveals a 'real' decline in Phase Two of 31% of those sketches which contain three or less SGAs (Phase One 74%, SD 5.6; Phase Two 51%, SD 10.8) do so. The t-test produced a result approaching a very highly significant difference (p=0.002) for a two-tailed test while the Mann-Whitney test indicates a highly significant difference (p=0.011).

These sketches which contain three or less SGAs (which may be shared or not shared) may be viewed as 'thumbnail' sketches. They will be familiar to most who have been engaged in creative graphic work. They are characterised as fast, transitory sketches which may be used to communication particular phenomenon (such as the size of a hole
or the outline form of an artifact) or as a private, developmental device used in conjunction with an internalised creative processes. The findings reveal that these thumbnail sketches were much less used in the remote condition but the effect was less easy to identify given the lack of significance in the difference in design quality ratings.

The t-test and the Mann-Whitney test have provided clear evidence of significant differences in output between the two conditions. Nevertheless, there were more observations concerning the data which usefully informed the conclusions in Chapter Fourteen. The following sub-section explores some of these wider observations before the final part to Chapter Thirteen.

13.3 Further Discussion and Speculation

Chapters Eleven and Twelve proposed the existence of Graphic Act profiles - most importantly, SGA profiles. These profiles consisted of peaks and troughs in SGA production and they were evident, to a greater or lesser extent, in all studies. An important relationship developed between the subjects in the studies. In some studies there appeared to be a marked adjustment of the production on GAs by one partner in response to the output (or the lack of it) by their partner. In Study 2, Phase One, the SGA output was approximately even in the second time band. In the subsequent two time bands SGA output decreased for Partner A while for Partner B it increased. In the very next time band the situation was reversed with Partner B presenting the decrease in SGAs while Partner A was increasing their output. The next time band presents another reversal with a high output of SGAs by Partner B. There could be two reasons for this. It may be that one partner reduced their sketching thereby allowing the other to take the lead. This might have come about if one partner had seen no useful way forward or was immersed in contemplation of a particular part of the problem space or a proposal. This may consequently have provided uninterrupted access the drawing pad and allowed the partner the necessary space and time to externalise their thoughts via GAs. The other possibility was that one subject took physical control of the drawing pad to such an extent that their partner was forced to reduce their sketching activity and thus their output of GAs. This might have come about if one subject felt he or she had an insight into the problem or a possible idea for resolution. The former might be viewed as 'passive', where one partner allowed the other to change (usually increase) their output of GAs as a result of inactivity. The latter might be viewed as 'active' because an increase in GA activity by one partner forced a decrease in GA activity by their partner. It was impossible to discern from the graphs or the video which of the two causes were operating. All one can reasonably say is that there appeared to exist, at certain points, some form of compensatory increase or decrease in GA activity between partners.
Many of the six studies of Phase One contained situations where one subject became animated, leant over the sketchpad and dominated the production of GAs as well as the discourse. Typically their partner would lean back in their chair, listen and observe and this could last many minutes. There were other occasions where one partner appeared deep in thought. He or she was producing no GA output and, more significantly, was not attempting any other form of communication such as discourse or eye contact. In such a situation the other partner often took the initiative by increasing their WGA or SGA activity. Of course, there were also situations when both partners became animated together and a process of turn-taking (or to a lesser extent simultaneous sketching activity) took place. There also occurred situations where both partners were still and these accounted for the joint dips in GA output in some studies (for example, time band 7, Study 2 or time band 7, Study 4, both Phase One).

Studies 3 and 5 in Phase Two displayed their highest production of WGAs in the early time bands while other Phase Two studies reveal a modest increase towards the end of their hour. WGA activity was low in all Phase Two studies around the middle time bands. As with Phase One this resulted from partners beginning their task by analysing the problem verbally - making written notes as they clarified and determined the problem space, before moving into sketching activity. Similarly where there was an increase in (or a return to) the use of WGAs towards the end of a study (as seen in Studies 1, 4 and 5 of Phase Two) this seemed to arise from subjects annotating a final proposal or from listing other design details still requiring attention. Most subjects exploited WGAs and the dramatic imbalances in this type of output between partners which was seen in Phase One does not appear in Phase Two.

It is possible that the limitations of such computer mediated collaboration resulted in partners agreeing, tacitly or otherwise, to take turns to lead the output of SGAs. It might also have been to do with a dominance (temporary or otherwise) of one or other partner. It might have been a practical issue in that they simply could not sketch and watch their partner at the same time but this would not answer why such turn-taking was visible across large chunks of the available time and not homogenised within individual time bands.

The bar chart data which emerged from Phase Two are, in many ways, similar to those generated from Phase One (Appendix V). The distinctive profiles seen in Phase One can be discerned in the charts of Phase Two. These profiles were discussed in Chapters Eleven and Twelve and it was proposed that there existed complex dynamics between participants engaged in such collaborative work. Far from seeking to establish smooth profiles of WGA and SGA output, environments aimed at supporting remote collaborative design may have to acknowledge the erratic profiles exhibited by the Phase One participants. These studies revealed times when participants mirrored each...
other with their SGA and/or WGA output rising and falling together. At other times there existed a distinct opposing of GA output and this might be 'active', as one participant forced their partner to reduce output (perhaps by leaning over the drawing surface, or using a verbal device for gaining attention) or 'passive', where a lull in activity by one partner facilitated an expansion of GA output by the other partner. If Phase One profiles of graphic activity represent the preferred graphic output for the collaborative resolution of design problems then Phase Two profiles display, perhaps for various reasons, impoverishments to such output. Thus Phase Two, with its computer mediated condition, seems to indicate a poorer quality of collaboration.

It might be speculated that sketches and sketching in the remote condition had a more significant role in supporting communication between partners. In the proximal setting communication via such channels as gesture, eye contact and voice was straightforward and sketching appeared to be easy via familiar tools. New sketches were easily made and easily explained where they were not clear to the partner. In the remote setting communication perhaps required more effort in sending and receiving signals and the sketches may have been more difficult to make. Also, it can be speculated that while the headset telephones may have been good at supporting spoken dialogue, gestures required more effort to exploit them successfully and this effort may have intruded into other communicational or creative activity. Sketches in remote designing appeared to act to support communication in a far more explicit way than was the case in proximal designing. It had been considered that some remote subjects may display a preference, after a volume of work has been produced, to work into (and sometimes over) existing sketches rather than start new ones. Perhaps this is because existing sketches can possess aspects of a shared understanding which might be difficult to achieve if either partner were to construct new sketches. The absence of significance arising from the statistical tests would suggest no such preference but other tests for this perhaps need to be applied. Perhaps such 'new' sketches are important to collaborative designing? Perhaps to impoverish them is to impoverish the quality of the collaboration and the quality of the output. It would certainly seem to be one possible reason for the increase in SGAs committed to shared sketches (Rows L & M, Tables 3 & 8).

13.4 Overall Findings of the AGA Project

* Remote participants spent 51% more time making graphic acts than their proximal counterparts. This was statistically significant. Partly this can be explained by the existence of extended periods of non-drawing time in the proximal studies.

* No significance was found in the differences in design quality assessment between the two conditions.
* There was a 30% decrease in overall drawing production when subject pairs worked remotely. This might be associated with a lack of familiarity with the computer tools or inherent restrictions such as screen (page) size.

* In spite of producing a 17% lower mean number of sketches in the remote condition, the mean number of shared sketches was 31% higher. This suggests that remote pairs found it preferable to work-up their own sketches, and those of their partner, in their collaborative designing rather than begin new ones.

* No significant difference was found in the production of Sketch Graphic Acts (SGAs). Remote pairs were just as able as proximal pairs to generate these in their collaboration designing.

* There were 37% more SGAs per sketch in the remote condition and, statistically, this was highly significant.

* 52% more SGAs were committed to shared sketches in the remote condition.

* The remote condition presented a 'highly significant' 42% decrease in the production of sketches with three or less SGAs (characterised as ‘thumbnail’ sketches). When this was corrected for variation in overall sketch output there was still a 31% decrease in the output of this type of sketch.

* While the Graphic Act profiles of the remote condition displayed some similar features to the profiles resulting from the proximal studies, they did not possess the same levels or iterations of activity.
Section 4 Summary

Section 4 presented the ROCOCO project at Loughborough University as a significant research project in the field of computer supported collaborative working (CSCW). Broadly, it sought to compare the activities and output of pairs of student product designers who conducted their collaborative design face-to-face with similar pairs who were located remotely but linked by computer mediated audio, video and drawing tools. The section has also presented design activity, and particularly industrial design, as an appropriate context for research into CSCW.

The Analysis of Graphic Acts (AGA) project was a complete revisiting of the drawing evidence collected by the ROCOCO project and it produced new data. Graphic Acts, and particularly Sketch Graphic Acts (SGAs), have been shown to be useful indicators for research into drawing within collaborative designing. They can be used to construct profiles of sketching activity and they are helpful in determining the extent to which sketches are jointly constructed or shared.

The AGA project exploited parametric and non-parametric tests via the SPSS computer based statistical programme in order to identify significant differences in SGA production between the proximal and the remote conditions. Remote pairings spent 51% more time sketching without any significant increase in quality of design output; they produced 30% less drawings but 31% more shared sketches; and each shared sketch contained a greater number of SGAs when compared to the output of proximal pairings. Importantly, output of 'thumbnail' sketches (consisting of three or less SGAs) was 31% lower when pairs conducted their design teamworking via computer mediated tools.
Section 5

Reflection and Recommendations
# Chapter Fourteen

## Drawing and Designing: Overview and Recommendations

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14.1 Drawing and Designing

The topic of this Programme of research has been drawing and in particular freehand drawing or sketching. Sketching plays a part in the social, cultural and economic life of many people but this research has focused onto sketching within design activity - particularly industrial design. Sketching has been shown to have functions within the wider phenomenon of modelling for design and this functionality, and the consequential value, needs to be appreciated by two key groups. The first is design education, where competition for timetable space from other subjects, and from within the subject, has put the teaching of drawing and sketching under pressure. The second group includes those who devise and construct the support systems for modern design practice, particularly the developers of computer systems which purport to facilitate collaborative concept designing. While the two projects within this Programme have sought to document the functions and value of sketching for these two groups particularly, it is proposed that the research has produced new knowledge which illuminates the practice of design. The research may, therefore, be of wider value.

As part of the conclusion to the Programme the author contacted a number of professionals active in modern product design and development. Some of these were specifically involved with industrial design. Others had wider developmental responsibilities, for example, electronic engineering, but had interaction with industrial design activities. Of the respondents, two were from the Motorola Research Laboratory at Basingstoke (Kevin McKoen and David Bourne); one was from Black and Decker Ltd in Spennymoor, County Durham (Lawrie Cunningham, Industrial Design Manager, Consumer Products - Europe); and one was from Sans Design in London - a major product consultancy (Robert Woolston, Senior Designer). Each was provided with a summary of the findings of the NSEAD project and the AGA project and were asked to comment on the findings in relation to a) their own experience of the functions and value of sketching in design practice and b) their perceptions of the need for, and ability of, computer based systems to support sketching in remote collaborative designing. Various comments are included in this Chapter.

While sketching is perhaps one of humanities oldest means of expression never before have we had such a variety of media with which to construct sketches. One manifestation of this variety is the increasing power and affordability of computer based communication systems for making, saving and transmitting sketch images. Much of the developed world now takes for granted the sophisticated technology which enables all from the very old to the very young to construct, manipulate and communicate sketches on computers and which would appear to rival traditional media such as pencil and paper in its convenience and capacity.
Designing, and particularly that range of commercially oriented activities undertaken by designers of products of mass consumption (including, for example, graphic products and industrially mass produced artefacts), has experienced dramatic changes as a result of technological developments combined with a heightened need for competitiveness. Chapter One has discussed how commercial pressures for reducing expensive lead time have operated in parallel with technological developments. These have made computer based working almost essential for the product oriented professions and related professions such as architecture and engineering. Computer based working allows data to be used in various ways. It can be used to generate pictorial information but it can also facilitate various types of analysis. Computer based working facilitates the sharing of information and it has emerged at the same time as a renewed emphasis on groups and the synergistic benefits of teamworking in business and commerce (developed in sub-section 14.2).

This research programme was based on a perception that there could be real problems with such a supply led phenomenon. It was felt that little research existed to guide the future developers of technological systems for computer based designing in teams. Many tools were, and are, being released onto the market by companies who lack essential understanding of the nature of creative designing. Even more astonishing, at the start of this Programme, was the lack of information about the functions and importance of sketching within design activity. It appeared that commercial design practice was in danger of being directed by the potentially inadequate tools it used. The situation confronting design education was equally disturbing since many design curricula, and particularly those in higher education, attempt to address the needs and working practices of the design professions who themselves appear to be so dependent on the computer industry. The project sponsored by the National Society for Education in Art and Design (NSEAD) and the Analysis of Graphic Acts (AGA) project were this Programmes’ response to that perceived need for new knowledge about the value and functionality of sketching for designers. They have offered findings concerning the relationship of sketching and industrial design within what has been termed computer supported design teamworking.

Chapter One identified a potential confusion with the term drawing in that it may be used as both a noun and a verb. One priority for the drawing research community (which is a small but international one) has been to undertake some form of definition of terms but to date the subject has defied attempts to establish an agreed taxonomy. There is considerable interchangeability in words used to describe drawing as process and drawing as output. It has been proposed in this thesis that drawing forms part of the wider ‘language’ of modelling, locating drawing research within the wider field of design research. Sketching, as a particular subset of drawing, has been shown to support communication in much the same way that other, more formalised, drawing
conventions can do. However, the potential for sketching to support creative and developmental activities dominated the NSEAD transcript analysis since this capacity appeared to be the least understood or appreciated outside of the tacit knowledge of the design community. Sketching has been shown to make a unique contribution to the transformational processes which exploit human cognitive capabilities and external, constructed models. This capacity for sketching to support the 'emergence' of ideas is currently occupying a number of researchers. It is not just the potential speed of sketch generation which assists cognitive processing. The very lack of clarity inherent in freehand drawing may be an important catalyst in the creative transformation. Ambiguity in sketches is presented as positive, rather than negative, for certain stages of the design process.

14.2 Sketching and Collaborative Designing

Sketching has been presented as essential to a wide range of professional designers. The NSEAD project documented this value thoroughly. These values still pertain when designers are required to move from individual working to working in teams but very little research exists which attempts to document the use of sketching as a modelling device when designers collaborate with others. As noted above, commercial design is increasingly becoming a computer based practice and it is also now almost exclusively a group activity. There may be lone designers operating in, for example, the crafts or fashion world but largely the professions are characterised by teams of specialists with particular roles. This has been facilitated by the explosion in communications technology providing, for example, cellular phones and facsimile machines, and computer based tools providing electronic mail, file sharing, and in some cases teleconferencing.

The 1980s saw a significant increase in group working in business and commerce with considerable variations in group size. Where face-to-face meetings were deemed necessary, and where individuals operated within the same geographical area, then the mechanics of such meetings were straightforward. Increasingly throughout the 1980s, potential participants were distributed over distance - mergers between remote companies, the use of consultants, the broad distribution of expertise and pressures to reduce lead time all worked to make travel by some or all of the participants necessary. The objections to travel on the grounds of costs, time, inconvenience and ecological unsustainability grew in parallel with the pressures to undertake such travel. Lawrie Cunningham at Black and Decker believes:

`...the use of computer media in teamwork, where the team may be remotely distributed, has increased vastly in the last few years and will continue to do so. This has been occasioned by the need to convey data between the team (and

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between teams) in, say, America and Europe, or Europe and the Far East, and it is a necessary feature of working globally and concurrently. Extensive use of internet and FTP (File Transfer Protocol) communication takes place - this is the post-concept phase of a project'.

While computer based communication within design and development is seen to be on the increase it would seem that it is more likely to to be used to support a project once a concept is established. This should be viewed alongside a comment from David Bourne at Motorola:

‘Sketching is a very good tool for discussing initial concepts. Ideas can be quickly discussed and enhanced. It is also vital in discussions between the electrical designer (say) and the mechanical designer to explain limitations of the design in terms of functionality or spatial limitations. These can be discussed and explained rapidly and with more understanding than with a formal specification’.

For the design community face-to-face meetings have always been important. They have a function at the conception of projects where the quality of the briefing can depend on the quality of human interaction. Face-to-face meetings also appear to be important to other creative and developmental phases of activity, either between designers or between designers and other participants. Part of the importance of face-to-face meetings for designers has been their ability to facilitate sketching as part of a two-way dialogue. Where such a dialogue is deemed to be unnecessary, or where face-to-face meetings are not feasible, then designers have taken very readily to the facsimile (fax) machine. The widespread exploitation of fax technology highlights the continuing value of pictorial imagery, including sketches, in design activity - particularly where it is supplemented by telephone discourse. The exploitation of fax communication also highlights an important feature of collaborative design activity. That is, designing exploits periods of synchronous activity (communication between participants in real-time), and asynchronous activity (communication which is staggered over time). While synchronous working has benefits at some stages of the design process, particularly the creative and problem-formulating phases, the advantages of tools to support asynchronous working for busy professionals who are multi-tasking is obvious. This is particularly relevant where activities take place across several time zones. The fax machine has proved particularly useful because of its ability to support both synchronous and asynchronous working.

The 1990 have seen the continued development of technological tools to support asynchronous and synchronous working within business, commerce and industry. These have been increasingly applied to synchronous and asynchronous communication within leisure activities. The rate of development has been dramatic.
Costs of computer hardware and software have decreased in real terms as the capability of machines increases, availability and technical support is rapidly improving, and telecommunications developments have facilitated the linking of computers in local and global networks. The boundaries between individual working and wider interactivity have become blurred. Computer based working now allows individuals to work alone or collaborate with others from their work station. Participants can search for information held in widely distributed sources via the World Wide Web and can share and transfer digital files. The potential for the design community is immense and there has been considerable investment in tools which facilitate computer aided design (CAD). However these tools are in an early state of development, often placed in market places by manufacturers keen to witness the types of exploitation made of new features and facilities. Some tools were never intended to support design activity and an on-going process of adaptation can be seen. The phenomenon of computer aided industrial design (CAID) is one instance of such adaptation where the developers have had to rethink the way that computer based tools support the cognitive processes and meet the requirements of the industrial design community.

Clearly computer based tools which facilitate individual working, communication and sophisticated collaborative working have applications outside of design. For many professions computer based working is a present reality. However, one of the major hurdles to the uptake of computer supported collaborative working within the design community is the poor match between requirements and facilities which results from the low level of research. Where computers seek to emulate existing capabilities then acceptance within design is generally high. For example, where an individual creates or independently develops CAD files or where computers offer facilities for asynchronous working such as electronic mail (email), attached files, or voice mail these can be readily integrated into existing practice. Similarly with computer based facilities for synchronous working such as an audio channel or the more sophisticated teleconference tools for audio and video links. What the design community requires to supplement these is an appropriate means of supporting synchronous sketch activity at those times when it is required. This will only come about as a result of appropriate research and development. Kevin McKoen at Motorola:

'I would estimate that display technology could be a limiting factor in computer supported team design activities. Paper is a cheap, high resolution and high contrast, large and light display format which doesn't yet have an electronic counterpart'.

The priority for the drawing research community no longer concerns the value of sketching for individuals - it must now focus on the role of sketching within computer based environments for what has been termed 'computer supported design'.

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teamworking' (CSDT). This programme has sought to address this via the NSEAD project, which documented the opinions of designers on their individual work and their work in teams, and the AGA project which compared the sketching activity of simple remote teams undertaking CSDT with others operating in a more traditional, proximal context. The findings are intended to support the continued development of CSDT environments but may well have application in the broader field of computer supported collaborative working.

14.3 Sketching in Computer Supported Design Teamworking

The Remote Communication and Collaboration (ROCOCO) project undertaken as a multidisciplinary project at Loughborough University between 1988 and 1992 provided the rich source of video and drawing evidence for the revisiting process which has been titled the Analysis of Graphic Acts (AGA) project. The ROCOCO project determined the particular configuration of hardware and software which emulated a sophisticated environment for computer supported collaborative working and it defined two broad conditions for its studies. It sought to compare pairs of design students collaborating proximally on a shared design task with other pairs collaborating remotely but linked by computer based tools. For the purpose of the AGA project only the evidence relating to the six proximal studies (referred to as Phase One) and five remote studies exploiting all the communication tools of headset telephone, video link and shared drawing surface (referred to as Phase Two) was used.

Table 9 in the previous chapter has succinctly highlighted the significant differences between Phase One and Phase Two via the AGA project and a detailed commentary supplemented this. The research adopted a focus on the comparative output of Graphic Acts - particularly Sketch Graphic Acts (SGAs) between remote and proximal pairings. Remote participants spent 51% more time making Graphic Acts than their proximal counterparts and they displayed a 30% decrease in overall drawing production. When pictorial drawings (or sketches) were investigated it was found that in spite of producing a 17% lower mean number of sketches in the remote condition, the mean number of shared sketches was 31% higher. This suggests that remote pairs found it preferable to work-up their own sketches, and those of their partner, in their collaborative designing rather than begin new ones.

Interestingly, no significance was found in the differences in design quality assessment between the two conditions. However, it is worth noting that three proximal studies produced a design quality assessment rating of over 70% while the highest rating for a remote study was 63% (Row B, Table 9). There is little evidence to suggest why these produced the higher quality rated output within their conditions. The three proximal studies which achieved over 70% produced 59% of the shared sketches (Row G, Table...
9) while the top three ratings of the remote condition (63\%, 63\% & 53\%) produced 63\% of the shared sketches so possibly the sharing of sketches may have assisted participants to achieve a better proposal. When the same studies were examined with respect to SGAs applied to shared drawings (Row L, Table 9) then 57\% of SGA production was found in the best three proximal studies, while 61\% of SGA production was found in the best three remote studies.

Of the statistically significant findings, the following were highlighted in Chapter Thirteen. Pairings in the remote condition produced 37\% more SGAs per sketch and 52\% more SGAs were committed to shared sketches. There was a 'highly significant' 42\% decrease in the production of sketches with three or less SGAs. When this was corrected for variation in overall sketch output there was still a 31\% decrease in the output of this type of sketch which was characterised as 'thumbnail' sketches in that they were fast and transitory with only a fleeting (but potentially vital) function.

Chapter Thirteen also draw attention to the Graphic Act profiles of the remote condition which, while displaying some similar features to the profiles resulting from the proximal studies, did not possess the same levels or iterations of activity.

The mean time spent drawing in each condition has been shown to be significantly different - suggesting that for some reason remote partners needed to make greater use of their stylus than would be the case if they had been located proximally and used traditional pen and paper. It has been proposed that drawing was perhaps being used to maintain a common focus of attention on the monitor screens, that is, as a 'pointing' or 'attention-getting' device. The proximal studies revealed substantial periods of non-drawing activity. In the remote studies, physical movements were perhaps less apparent and the more frequent use of drawing may have been an attempt to compensate for this.

With regard to the 31\% decrease in overall drawing production in the remote condition this might have been to do with a lack of familiarity with the computer based tools or it might have been related to differences in available drawing space. It might also highlight a preference to work-up existing drawings rather than instigate new ones. Producing less drawings overall is not necessarily important. It may be that subjects worked more efficiently, especially when one considers that no significant difference was found in the design quality assessment.

In the remote condition idea development and design progression seemed to proceed via a process of 'modification' of ideas rather than 'creation'. While shared sketches are probably important to the dynamics of design collaboration an over-reliance on shared sketches may have a suppressive effect on the progression of a design where they

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restrict new drawing. Also, it would seem logical that drawings in the remote condition had a more significant role in maintaining communication between partners. In the proximal setting communication, via such channels as gesture, eye contact and voice, was well supported and drawing exploited very familiar tools. New sketches were easily made and easily explained where they were not clear to a partner. In the remote setting communication had to be worked at - partners had to consciously send and receive signals and the sketches would appear to have been far more difficult to make. While the headset telephone may have been good at supporting spoken dialogue, gestures required more effort to exploit them successfully - and, in attempting this, they ran the risk of intruding into other communicational or creative activity. Sketches produced in the remote condition seemed to be used to support communication in a far more explicit way than was the case in the proximal condition.

Remote subjects demonstrated a preference to work into (and sometimes over) existing sketches rather than start new ones, perhaps because existing drawings contained a level of shared understanding difficult to achieve in new sketches. If new sketches are important to collaborative designing then the tools need to support this.

14.4 Summary of recommendations for CSDT system design

A system for computer supported design teamworking must offer suitable support of a number of communication modes such as voice and gesture. This aspect lies outside the remit of this thesis. One of these communication modes (it is actually a mode of development as well as communication) is sketching and CSDT systems have yet to appropriately support the sketching requirements of its participants. It is here recommended that CSDT systems should:

* offer an interface which does not appear to be complicated. It need not offer multiple variations of sketching tools, pages and other related facilities. The input devices should offer the flexibility and familiarity of traditional media such as pens and paper sketch pads. It should be suitable for use by participants with no formal training in sketching

* facilitate the construction and development of graphic models such as pictorial sketches, written text and mathematical notation as least as well as face-to-face drawing which uses traditional media such as pencil and paper

* support teams of participants as well as support individual working. While the size of design teams appears to be increasing a CSDT system may not need to support all team members at once.

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• be compatible with the demands of synchronous and asynchronous working

• support transformational processes involving creative, developmental and evaluative strategies in design and development - particularly creative strategies for problem formulation and idea generation

• enable participants to interact simultaneously with any image on display. Graphic acts should appear instantaneously on the screens of all participants where required to

• enable switching between pages but, if parallel working on different pages is permitted, to facilitate easy finding of their own current output and output (current and previous) of other participants as required during teamworking

• support the ability of participants to attract or maintain attention of a partner or partners, and to direct this attention towards a particular drawing

• facilitate ambiguity in sketches where this is required, and to facilitate clarity where this is required

• facilitate the speedy construction of sketches; the construction of new sketches and those sketches comprising of few graphic acts.

• facilitate the sharing of sketches where this is deemed desirable by the participants

• offer sketch pages at a convenient size to view output - particularly facilitating comparisons between sketches on a page and between pages. Face-to-face designing still commonly exploits pages of A3 and A2 in size.

• offer an integrated resource compatible with other CAD, CAID and rapid prototyping facilities, plus integration with other information technology tools such the World Wide Web and email

• facilitate intra-organisational working; inter-organisational working; and international working.

14.5 Reflections on Design Methods

At the outset of the Programme it was not at all certain what research methods were suitable to a study of drawing activity. The subject itself displayed numerous arbitrary divisions. Drawing is manifest in many aspects of the arts and sciences and the
purposes for which it is employed vary enormously. This programme has focused on sketching as both activity and graphic output and it has done this within a relatively small sector - namely design. It is relevant to ask whether information encoded as graphic output can ever be adequately expressed in natural language. Drawing and the range of human capabilities concerned with drawing which gave rise to the termed 'graphicacy' as far back as the 1960s (see Balchin & Coleman 1965) appear to have an operational relationship with human cognitive processes which is non-verbal. One should treat constructions of so-called evidence with caution.

Laboratory studies of drawing, such as those by Verstijnen (1997) as well as those undertaken in the ROCOCO project, may not be representative of the wider population. So much depends on the conditions and subjects at the time of the studies that conclusions can be potentially misleading. There is a distinct danger, as with all experimental work, that the variable, contextual factors are so all-pervading that the findings only have validity for the particular conditions of time and place in which the research was conducted. This programme of research exploited two different research strategies in two separate projects. The first was an observational study aimed at illuminating the functions and value of drawing and sketching for designers. The second was a closely controlled comparative study which sought to examine, via analyses of graphic activity and graphic acts, the differences in drawing activity between proximal collaborative designing and computer supported remote collaborative designing. This Programme of research into drawing may be viewed as an inquiry into appropriate research methods as well as an inquiry into the functionality of drawing for designers.

The NSEAD/Berol bursary project was intended as a foundation to a programme which had yet to be defined. It had to be divergent and illuminative - to establish boundaries to a subject that was ill-defined and it fulfilled this function well. The initial proposal was based on subjective and anecdotal evidence regarding a relationship between drawing and designing. This was compounded by poor and incomplete articulation of drawing via design research publications of the 1980s. It was believed that design practice and design education would benefit from a clearer articulation of drawing and sketching. The NSEAD/Berol bursary project exploited a focused interview technique and this proved itself effective for generating relevant material. It has led to over twenty papers and conference presentations by the author. It has been influential and continues to be cited by eminent researchers in current work (see Archer 1997). The full transcripts have been appended to this thesis so that future researchers can construct alternative or additional meaning from the raw data. They also provide a complete picture of the conduct of the interviews including the nature of the questioning.

One might reasonably raise questions regarding repeatability of the NSEAD research
but the success of the project in making a contribution to knowledge should be measured by its ability to highlight functions and values of drawing. The fact that the subjects were limited in number and selected by the author does not invalidate the findings which make no claim to have discovered all there is to know about the phenomenon. Opportunities for rigorous cross-referencing or triangulation of findings were limited but each interview understandably influenced the subsequent ones. The analysis explicitly avoided any statistical interpretation which would have been meaningless given the nature of the subjective responses.

Research into computer supported collaborative working was influenced by a much broader debate regarding research into Human Computer Interaction (HCI). Part of the debate concerned the lack of generally accepted opinions regarding the procedures and requirements for designing in teams but much of the evidence was extrapolated from studies of individual designers and this came to be recognised as limited in its use. For the wider research community it became apparent in the mid-1980s that research into design teamworking was necessary and by the early 1990s it was identified that ‘in order to understand and support design activity as it actually happens, we must begin to appreciate design practice as an intricate and complex social and technical undertaking’ (Minneman and Leifer 1993). A significant element of research into collaborative design work involved attempts to establish understanding of how groups constructed and jointly developed the shared models which represented the output of collaborative design. Sketching was the focus of a number of studies around the world at this time and debate was emerging concerning the relative appropriateness of methods of research into sketching (see Wood 1994). There was also growing debate concerning the role of sketching in the emergence of ideas and the ability for sketches to represent shared understanding.

The study of sketching activity is not new. It has fascinated theorists and practitioners from many fields, particularly the arts, for centuries. However, the advent of powerful computer and telecommunication technology has stimulated interest in this rather opaque subject. More particularly it has stimulated research into the comparative merits of traditional aspects of sketching (for example, using pen and paper) when compared to the practice of computer based sketching within synchronous and asynchronous systems. The ROCOCO/AGA project was an example of closely controlled laboratory studies of computer supported synchronous design teamworking where participants were remote.

The 1990s has seen a process of reflection by this small research community regarding the relative merits of research methods for such studies. A broad division exists between those who follow a classical cognitive science strategy and choose to conduct studies in closely controlled conditions and those whose sympathies lie with research.
paradigms of the social sciences and who argue that such studies are too intrusive to yield valuable information. There is no easy resolution to this debate for the drawing research community. If one is attempting to understand the social organisation of work then any research which removes most of the context and places 'participants' in a 'white room' is bound to have its potential limited. However, the potential variability in subjects of study may rule out comparisons of the findings from observational research. This Programme has attempted to exploit the advantages of both strategies while acknowledging the disadvantages.

Cross et al (1992) has highlighted the weakness of using experimental studies to document design procedures. They highlight, with reference to a number of studies, the impoverishments to the dynamics which take place within 'real' design activity. However, The AGA project was not a study of designing; it was a study of the changes in drawing activity which took place when pairs of design subjects were moved from proximal to remote working and where they had to use computer based tools for any sketching activity. It was not an attempt to replicate design as it might be found in the outside world and from which conclusions could be generated about computer supported design teamworking. It was a particular comparative analysis where the variables were substantially controlled in order to learn something about the exploitation of drawing within conceptual designing via a process of graphic act analysis.

With the benefits of hindsight the Rococo studies, on which the AGA project depended, would have been tackled differently. Firstly six pairs of subjects would have been involved in each condition to overcome the six to five comparison. Ideally each study would have used the same brief - or at least the same selection of briefs - for each condition so as to reduce opportunities for differences between conditions. Also, it would now seem sensible to have used each pairing in both phase One and Phase Two to further enhance the confidence in findings concerning differences in output between the two conditions.

14.6 Directions for Future Research

The commercial availability of tools for computer supported collaborative working has generated a broad research interest in the functioning of sketching between distributed participants. Research into the exploitation and integration of sketched graphic imagery within communication between distributed participants could have value for many fields such as education, administration, the military and leisure. One potential application of the findings emerging from this programme concerns the use of sketching between distributed medical staff. A consultant running a Radiology unit in a major overseas hospital uses sketches to communicate with his junior staff. He draws onto x-rays to highlight his concerns and to instruct on actions. He wishes to continue his practice of
asynchronous working which can be supplemented by the telephone or meetings when necessary. Much of his communication is now via electronic mail (email) with the x-rays being distributed as attachments to email. The consultant and his staff use commercially available applications which do not fully meet their needs. The consultant perceives a market for a developed and improved sketching interface relevant to his work and this is currently being explored by the author.

However, it is in the design and design-related professions where new knowledge concerning computer based sketching could have the most significant long-term effect. Studies of sketching activity within design teams are not common but some of the landmark projects have already been discussed in this thesis. While Bly’s work published in 1988 provides one of the seminal studies of the 1980s, Wood (1994) highlights this growing research interest in the sketching activity which takes place between designers. Some of these studies exploit industrial design activity and involve participants who would refer to themselves as industrial designers (Ballay 1987). Other studies are drawn from architecture (Goldschmidt 1991) and mechanical engineering (Ullman et al 1990).

One of the most urgent requirements in this area of research is the construction and trialling of new sketching tools. There have been significant developments into stylus and tablet technology leading to sophisticated and elegant hardware allowing, for example, pressure sensitive surfaces with textures which emulate the feedback of pen and paper. Bearing in mind the key findings of the AGA project, new environments need to be constructed so that an enhancement of the quantity and quality of sketching activity can be further explored. The research presented as the ROCOCO/AGA project used student designers for convenience. It would be very useful to reproduce the studies with practising and/or experienced designers who may have a very different approach to the application of sketch imagery within their work. A development of this would be to pick up the issues of Chapter Two and undertake a more ethnographic observation of a commercial design situation. Such a study would require the construction of a CSDT environment for each individual involved in a selected piece of collaborative design and it would have to exist in their normal place of work. This has implications for cost, telecommunications infrastructure and technical support but it could potentially demonstrate a very different exploitation of sketching with remote collaborative designing - one which was less dominated by the educational context within which ROCOCO and AGA operated and one, perhaps, which did not seek to emulate pen and paper but which facilitated a unique response to modern technological capability.

CSDT environments potentially facilitate more than mere face-to-face meetings between two participants. While this was the context for the ROCOCO project there are now
numerous commercial examples of multi-user environments. Powerful teleconferencing environments can allow individual participants to undertake internet based searches and other activities such as file retrieval and then report back to the group in real time. Such parallel working is clearly compatible with moves towards increased efficiency such as via simultaneous engineering. If the meeting capability and the information retrieval capability are combined with powerful computer aided design (CAD) and/or computer aided industrial design (CAID) capability then one has a very sophisticated commercial tool. The design profession is currently at the stage of exploring this capability. It is one which is rapidly expanding - allowing individuals, who may be distributed around the globe, a wide range of means of interaction and thus freeing people from desk-bound computer workstations in favour of truly interactive, spatial environments. Rapid prototyping technology now allows conceptual and developed three-dimensional models of artefacts to be constructed simultaneously by all participants. These can then be held, evaluated and discussed within a very short space of time via the teleconference facility. Add to this the emerging capabilities for modelling ‘virtual’ proposals and the context of design practice can be seen to have changed out of all recognition from a few decades ago. 

This is where new research is needed. It is the practice of design within multi-user, virtual worlds which will characterise the top end of the profession. And yet designers will still need to externalise incomplete but emerging ideas for evaluation, development and communication. If virtual reality is to become the design tool of the future then what is ‘virtual sketching’? What form will it take? Do we know enough about the relationship between human cognitive processes and sketching with traditional media to be able to design the tools for virtual sketching? Undoubtedly sketching is one of mankind’s oldest means of expression and communication but it is logical to assume that its manifestation is closely defined by the media it exploits. If computer supported design teamworking is defining a new medium then perhaps new types of sketching activity and new types of sketch might result.


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## Appendix I

### NSEAD project interview transcripts

Transcripts of the interviews conducted for the NSEAD project into Drawing and Designing. The analysis of the transcripts appears as Section 3.

The following people were interviewed between August 1987 and August 1988.

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<td>Furniture Designer &amp; Head of Department</td>
<td>Birmingham Polytechnic.</td>
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<td>Graphic Designer &amp; Head of Department</td>
<td>BBC Television Centre, London.</td>
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<td>Director of Concept Engineering</td>
<td>Austin Rover (now Rover Group), Coventry.</td>
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<td>Pamela Howard</td>
<td>Theatre Designer &amp; Head of Department</td>
<td>Central School of Art and Design, London.</td>
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<td>Patrick Ireland</td>
<td>Freelance Illustrator</td>
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<td>Alan Williams</td>
<td>Product Designer &amp; Director</td>
<td>David Carter Associates, Warwick.</td>
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*Appendix I NSEAD project transcripts*
Interview 1
PETER ASHEN
Head of Department of Furniture Design, Birmingham Polytechnic.
Interviewed: 1.2.1988

SWG: Is drawing an important activity for you?

PA: When I came into education it was dominated by Arts and Crafts education. The design bit was only just growing and I came in simply as a student of arts and crafts under the control of the Ministry of Education. I actually went through a drawing course, part of which was called the 'drawing year'. Those years eventually wound up by developing into the Foundation courses. I wasn't given any particular attitude about drawing except that somehow it was good for you. I didn't know how it was going to be good for me and it was never explained but on reflection those two years were perhaps the two most valuable years of the whole of my education. I went on after that to do another three years in design education in Birmingham and another three years at the Royal College of Art. Those two years, I recognise now, formed a foundation of understanding of the world around me - the development of a visual literacy which makes me wonder how students who don't have the period of time to concentrate on drawing actually manage, how they catch up on the skills which I have developed. Not only the skills of drawing, which was drawing of all types, the subject area exercised you in the study of architecture, the history of architecture, life drawing, figure drawing, figure composition, anatomy, worked perspective and free perspective. These were all separate subject areas that were examined and you did a craft as well. The craft came into the drawing as a sort of one-day-a-week activity and we were taught the rudiments of working drawings during that period. So drawing at that time was not identified as the practice in drawing but the practice in anatomy, architecture, figure drawing, observation and composition and this led into the making of pictures. Drawing was used as a tool to create a visual literacy over a very wide front including the conveying of information in the way that designers convey it. It was that little bit of the drawing that I did during those two years which eventually grew into the major activity as a designer which was the drawing on the drawing board with a teesquare and set-square etc.

I look on drawing as means of gaining visual literacy. That is, you look at things with understanding and what you look at to a degree you can remember but certainly make some critical judgment of. If you spent say a hundred hours drawing buildings in a historical architectural way you could never look at a building again without noting the quality of the brickwork, the quality of the proportion of the windows, and all those
factors that make for visual literacy. After those two years of drawing I considered myself to be a painter. I was quite good at making furniture but it wasn't a prime interest, it was something I was fairly good at. We were all interviewed by the Principal of the College at that time to see what we were going to study. I said "painting" and he said "Ah! well I think you have done well enough in cabinet making to seriously consider that, haven't you?" The outshot of that interview was that he persuaded me to become the first student of cabinet making to do the National Diploma in Design. I wasn't too dismayed because it is a family background interest. The family have come from a furniture making interest. I was interested in it and I was fairly good at it. I was very disappointed in the painting thing but I thought there is nothing going to stop me painting, I don't have to be a student of painting to carry on painting. I knew enough about the business so for the next three years I continued with the painting activities, which had directly grown out of the drawing, and the development of design which had a very, very strong concentration on drawing techniques as a means of conveying information and ideas.

When I went into the army I continued drawing. I've got sketchbooks full of drawings, simply because it was a means of coming to terms with the world around me, new landscapes, new situations, new people. It seemed to me a way of making contact in a very real way.

SWG: Drawing seems to have an important reporting and communicating function for you but what about its function in the design process?

PA: Yes, well that really deals with the second consciousness of what drawing is all about. The first happened to me because I was required to do it and it is only in later years that I recognised the variety of values. Yes, for the whole of my professional life drawing has had a complex way of developing skills and the ability to communicate. I think first and foremost one has to say that if you have an idea in your mind, it is very rare that idea is seen in the round. The idea may revolve around a structural idea - an idea of the use of materials, even some stylistic details that you are interested in, but I always maintain that it is incomplete until I have got it down on paper and have drawn it from different points of view. As soon as you start drawing it you realise how inadequate your mental image is. You think you have got it contained in your mind but as soon as you put it down on paper you recognise there are facets of it that you can't really grasp just by thinking about it. So it is the first externalisation of an idea to test it.

Maybe you won't want me to talk about that aspect in my teaching at the moment but just very, very briefly I often say to my students "When you are drawing you should be drawing ideas that are in your head, don't let the pencil do the designing for you."
other words, a lot of students are quite, at the early stages, vacant of ideas and they draw things which they half-remembered hoping that it will gain some stimulus, some impetus towards a solution and I think that is a very dangerous and inarticulate way of designing. You should be able to sit down and think hard to generate ideas within the mind and then start drawing those ideas so that you are testing it against a mental image. So it becomes a sort of exploration. Designing is to me a most extraordinary occupation. It employs a capacity of the human animal, which we are told the other animals don't have, and this is the capacity to envisage, visualise and bring to fruition part of that visualisation. It is an extraordinary aptitude when you think that I can sit here now and I can think of a design for a chair, whatever material you mention, tubular steel, wood, plastic. I could design a chair in my head and think that I have got the basis of a good idea. Now, if I was doing this professionally, if someone had asked me to design a chair in tubular steel, then I sit down and I draw those ideas. Sometimes I realise they are not very good ideas but it is only through the drawing that I get the feedback which tells me what is worth developing and what is not.

SWG: Do you think training in drawing provides that mental capacity?

PA: Yes, because that mental capacity comes in the first place from visual literacy. I don't think you can conjure up ideas in your mind about how to construct something, how to design something, unless that visual literacy has been awakened in the first instance. I doubt very much if that visual literacy would be awakened by doing technical drawing, it would be by observational drawing, trying to record what you see, not just trying to remember it and record it. It is to do with understanding structure. You could never sit down and draw a tree without in the end understanding the nature of the growth of that tree. You know the natural forms. If you draw a man-made structure, a bridge, you could look at bridges in a vacant sort of way, admire the beauty of a bridge in a landscape but if you sit down and draw that bridge you are straight away brought face to face with the way it is constructed. In other words the material soul of that bridge exposes itself to you in the way it is put together, to create a beautiful or an ugly object. You don't always create beauty, of course. So when you have had practise at doing that I think then if someone says bridges or chairs or whatever, because you have looked long and hard at these things you are then able to conjure up reasonably accurate pictures in your mind, not accurate in detail, but accurate in overall concept. So I think that drawing in the first instance stimulates that ability to visualise ideas. Drawing is immensely complex in the way it interacts with designers.

SWG: In addition to analysis and communication what function does drawing have for the creation of ideas? Perhaps there is a case for putting down half-remembered or incomplete images so that the drawings and the mind react together?
PA: Yes, I think it is good advice for students to do that, I think it is a sort of arrogance on anyone's part when they believe they can think up an idea entirely in their head and all they have to do is put it down on paper. That probably leads to most of the ugliness in the environment today. Things are not sufficiently tested. When you look at things that are successfully conceived and built you find that they have undergone a very elaborate development, each stage of which entails modification and development of it. A student who thinks he has got it entirely encapsulated in his head and only needs to put it down is taking a very arrogant or very ill-educated view of the role of drawing. I think that some of the most intelligent minds that I have come across in the whole world of art and design are people who are extremely articulate in drawing. They tend to use their hands not to wave about but to hold a pencil and illustrate what they are talking about. There is a communion between what they are saying and what they are visualising and that visualisation often comes out in drawing. Sir Hugh Casson is a prime example of that. I worked for a time with Professor Dick Russell and he did very little drawing in a formal sense but when he was talking to you he was also drawing. In a way he was not only conveying ideas to the people who were responsible for developing the designs but he was testing his own ideas at the same time.

SWG: Do you find that you have developed a drawing shorthand over the years? If you were asked to make a cabinet for example, and you did not have to show any drawings for it, just a cabinet, what sort of marks would you make on paper to help you design and develop it, would it be the same as you did in the past?

PA: No, it wouldn't be the same as I did in the past because a lot of the information can be contained in a drawing which only I understand structurally. Now that doesn't mean to say that they are not drawings, hopefully, of some quality and some value. As a matter of fact I've got a pile of these drawings in a drawer downstairs which are my own exploratory drawings, which I often show students when they are trying to conjure up a design. I say "this is how I work. You don't have to work this way, it is just an example of how I work." Invariably my drawings will show a lot more modelling. I work accurately, on a drawing board and while I'm drawing it I am actually building it. It is a means of constructing it in my mind. I don't put in there all the details - joints etc., because I know where they are going and what proportions they will be but if I were doing the same drawing for a company I would produce a technical drawing which did show the joints or at least specify them quite accurately. The drawings I would do for myself are really rather different from the drawings I would do for a client. The drawings I do for clients have not changed significantly except let's hope that one's got a bit more practice over the years in conveying that information accurately and clearly. Clear information is paramount and that is the most difficult thing to do in the early stages of your design career. You take
these things for granted but a client will need every piece of information which is necessary to make it, which is very different from drawing for yourself to make things for yourself.

I quite deliberately try not to short-circuit things, if anything I tend to be disciplined and think I'll do what I tell my students to do because I don't tell them cynically you should draw things before you make them. I know it makes good sense because mistakes will become apparent in the drawing stage. One of my little comments when I am working with students, particularly the part-timers, the evening-class students, was "You don't make anything here until you draw it". I didn't know I was saying this but apparently I said it so often it was a bit of a joke amongst the class. Even in the evening class that I take I get them to draw their projects. Now this makes me realise why so many bad things come to fruition. People feel they don't need to draw, they don't need to explore the idea but the drawing process immensely modifies what is thought of an idea.

SWG: What are your feelings about the nature of design education within schools or higher education at present and particularly what role can drawing play in a field that is becoming increasingly more technical?

PA: This is where I begin to feel strongly about issues. There are strong warning signals coming back to me that Craft Design and Technology (CDT) is going well and truly up the wrong path. Of all the students that have applied to us, and there are a considerable number who have done CDT up to 'A' level, I don't think we have ever accepted more than one student and the one we accepted we have regretted. The great fault is that the emphasis is enormously towards the methodology, the laborious working out of all the technical details, the seeming thoroughness with which the whole thing has to be done. It misses out almost entirely on what makes an object worth making in the first place - that is, it has something to contribute, that it is beautiful, that it is well proportioned.

We see a succession from CDT courses of the most appallingly designed but incredibly well-detailed, ergonomic chairs for example, things that really have a very peripheral value to society or even to the students themselves, when they have finished them. So I am really quite skeptical about it. It has become an examination subject. I always value craft and art and pottery because they are processes which allow the student to develop from the creation of an idea, through the development of an idea to its ultimate realisation without pressure of an examination. I could look at a hundred folders and if forty of them came from CDT advanced level courses and the other sixty came from foundation courses, I would pick out the foundation course students straightaway, without any hesitation, because they have a flair, an investigative feel for the projects they are tackling and you look at the CDT and they are dull, technical, almost totally
divorced from the artistic. Now things may change. I realise that a lot of the people who have been drawn into the CDT teaching have in fact been themselves trained in a narrow craft sense. They are not themselves the creative designers that we would like to see working in CDT. So that is why I do put a slight reservation on my own comments that given time things could change and might in fact prove to be very good if you have got the right minds teaching at CDT level that understood the need to explore creative ideas in the first place and not to start this tedious technical development until that good idea had been somehow crystallised and drawn out of the students. The question that leaves is are the kids mature enough, old enough, experienced enough, to be producing designs of that quality. It may be that CDT is hitting them too early, that the CDT stages ought still to be the free, exploratory stages.

SWG: I presume you see drawing as an important part of that?

PA: Absolutely, yes. The thing that we always say to schools when we go visiting is "what relationship have you got with your art department" and invariably there is no relationship. Art has one set of inspectors, CDT and craft has another set of inspectors, and because of this the two don't mix. It is difficult because most artists are not designers, so just simply teaching drawing is not necessarily going to produce the sort of drawing that designers need.

I have never really separated off technology from my own interest in design because so much of it stems from technological interest. I have always been appalled by the tendency of some of the rather senior people in the professional world to say that design colleges ought to be separated from art colleges. That to me is possibly disastrous and the design college has got to include a vast amount of technology. I think you have got to be bathed in the technological thing including computer aided design where it is appropriate, not as something which supersedes other drawing techniques but as a development from it, No, I wouldn't like to see any separation of the two. I think the engineers haven't really matched up to what was expected of them in the modern world. They have contributed rather grossly to the ugliness of the environment because they are visually illiterate people. In the early stages of their training they needed really to be mixing with people of artistic skill and to be taught by people with artistic skill so that sensitivity - and this is not an appeal for ephemeral or meaningless contribution to society - but the beauty of one's environment is immensely important to the success of the civilisation and poor old engineers have developed themselves along the technological path where they are no longer sensitive in the way that Brunel was sensitive. Engineers such as Brunel cared about visual and technical details such as the width of the brass band around a funnel, things that a sensitive designer would care about it.
JOHN ASTON
Head of Graphic Design, BBC Television Centre, London.

SWG: While we may wish to talk a little about the activity of communicating ideas through drawing, I am particularly interested in the manipulation of ideas using drawing.

JA: Well, first let me say that in recruiting people into this business, into the specific craft activity of graphic design for television, we are in the moving-image business. We put an enormous amount of emphasis on drawing skill. We do not have any designers here who cannot draw. There is a quotation that I like that goes something like this: 'Drawing for designers can be compared for its influence with the Samurai sword, that it cuts through all argument and indecision and leaves your opponent precisely where you want him - astonished and listening to your point of view.' It comes from an ex head of a design group here who swore that it had come from some Eastern book, but I know that he made it up. It sums up how all of us feel here. The act of drawing is essential for lots of different reasons, you've already mentioned communication.

The designers client here will be a producer, a series editor, a programme controller, director. He will be a programme maker. You would expect programme makers to be highly visual people. Some are, for example those in drama, music or arts, they may know what they are looking at when they look through a lens - know what pictures are all about. But there are a hell of a lot of people who make programmes who do not, particularly word-oriented people such as journalists. The client is expected to describe the parameters of his problem, the designers brief is to solve his problem. In solving that problem he must communicate ideas to the producer, its absolutely essential that the producer has a very clear understanding of what his designer is going to do for him because there is going to be a price tag attached to it, a timescale attached to it, a resource budget, a lot of commitment. Once it gets past the pencil and paper stage, you are talking about a lot of money, so that pencil and paper stage is very important indeed. There is a need to communicate with all kinds of other people, technical co-ordinators, computer graphics programmers, animators, computer animators, illustrators, airbrush artists; the designer as art director must communicate well with all of them so there is a need for drawing skills there, but in the creative process it would be wrong of me if I said to you that it was an absolute requirement that everyone should be a first-rate drawer because some designers can dream dreams in their head and can
communicate using all of the skills available but at some stage you've got to get it down on paper somewhere.

Most of the designers, if not all, that we would employ here will begin their thinking process through that co-ordination of brain and hand and eye. It is an iterative process of making marks on paper. Bearing in mind what I first said to you about moving image, there has to be ways in which you can actually visualise moving image. The main way is through the storyboard process. So even if you are storyboarding for inclusion of live action, one must be able to visualise it and must be able to put it down on paper and that process helps to sort out how you are going to do it, what kind of approach. So it doesn't matter whether your storyboarding for live action or animation or drawing for logotype using letter-form which is just another form of drawing. We expect a very high degree of typographic skill, we are graphic designers after all. Logotype assumes a great deal of importance in television transmission, the establishment of style, corporate identity, or particular programme strands and so on. So I guess that's what I want to say to begin with, we do put an enormous amount of emphasis on that ability.

SWG: Do you find that drawing replaces natural language or does it assist in a wider relationship?

JA: I don't think it can ever replace natural language in our business because the relationship that exists between the designer and his client involves a whole team of people. One of the other things that we would expect of our designers is that they should be articulate, reasonably well educated, in fact very well educated. We are dealing with historical topics, topics that are geographically oriented in all parts of the world, and so on. We expect people therefore, to have a fairly wide cultural platform on which they stand so that they can draw the references from whatever compartment of their brain they may have been previously programmed into. So to be able to communicate using all skills is very important. It is interesting though, as I am talking I can think of at least two or three of our designers that I have enormous admiration for who are anything but articulate in terms of natural language but who would have no difficulty in communicating with anyone through the act of drawing.

SWG: Do you still use drawing in your day to day activity?

JA: As a design manager I have come through all the levels from young assistant through to designer, senior designer, in the ceramics industry, the publishing industry and now in television. If I have a problem then I tend to think in terms of drawings and I tend to put things down in note form, not in a beautifully ordered and organised series of notes but I tend to link things on scraps of paper in very much the same way as if
one were working through a design problem.

It would be quite unthinkable that anyone doing my job was not a designer or who had not been a practising designer full-time. There is a need for me to understand the design problems and to understand what designers are doing, to be able to talk with them, be critical of them and to be able to intervene if there are difficulties with client and so on. I do a lot of talking initially with potential clients. Someone will ring me and say 'John can I have a word with you about a projected series' or whatever, and this is prior to any other process. As they are talking I am usually doodling, a peculiar kind of doodling I suppose, because the one thing I must not allow myself to do is to start designing per se because I am going to assign one of our fifty or so designers to it and he or she wouldn't thank me very much if I had already caused some prescription to happen. So I would be thinking in fairly broad terms which would allow me to make a successful marriage.

SWG: Would you say you were trying to define the problem rather than to find the answer?

JA: Trying to assist the client in defining the brief, yes, very much so, because it is something which quite frequently happens especially with relatively inexperienced production people. There are very brilliant producers, directors, who imagine that a brief is to say "I want six of these and three of those and paint that yellow and by the way I need xyz". One usually says then "please stop defining what you think your solution is and try to define what the problem is". What usually happens is I will go through and ask lots of questions. There are a lot of questions for which drawing doesn't help you very much initially. I will need to know time slot, which channel, what's the audience target, what are the budget parameters and so on but you might then get beyond that into identifying with the producer actually what his expectations are as far as the programme is concerned, what kind of packaging he is likely to want, if any, what kind of spin-offs from that packaging, into pre-publicity, post-publicity, posters, hand-outs, invitations, or whatever, whether or not any elements of the graphic solutions have got to be translated into scenic elements, whether or not there is significant contribution from the designer of the programme to the content, how that actually relates to the content material. We could go through a whole list of stuff like that so there is a need to begin to help the client focus and in doing that if he is sitting with me it is likely that I will pull out a layout pad and there will be all kinds of scribbles all over it. I might even allow the client to scribble because the object of that exercise is for me to get close enough to be able to assist him in defining, for example, what kind of budget parameters we are into, what kind of timescale might be necessary, or what kind of aptitudes may be necessary from the designer who will ultimately work with him.
I am thinking of a particular case where one of our senior designers is extremely well versed in astrophysics. A short while ago we discussed the possibility of this designer working on a science show and then we changed our mind because the producer preferred to work with someone who had no preconceptions, but who could visualise in a different way, dream dreams from a zero start. So there is a need for me to understand what the strengths of other people are and also that I will make decisions at times on the basis of how well someone might visualise or draw. I have already said that we would expect all designers to have good drawing skills, but what does that mean? Visualising skills? Many of our designers are first-rate illustrators in their own right. If I felt that an illustrative approach to a particular problem were necessary, where the designer may have enough time to actually use his own drawing skills and not just to visualise the product - to be the product, then one might be tempted to make that kind of decision.

SWG: Does that happen very often?

JA: Yes, quite frequently. We have designers who are also very good animators in their own right. The designer can be a pure art director or he can be someone who does it as well, depending on how much time he has got. How much time he has got will depend on how much time I am giving him because part of my job is to ensure that we have a high level of productivity amongst the design staff. Quite a lot of the time though the designer-as-art-director is the person whose concept it is and who is just like a furniture designer, or an architect, or a textile designer, dependent on a whole host of specialised skills from other people who support the design activity.

SWG: What about other roles for drawing?

JA: If you are having to storyboard for an animator or an illustrator then a wise designer will make successive statements that are adequate for the overall control of that piece but will not deny the opportunity on the part of the animator or the illustrator to put their own ideas into it, to add to it and to surprise you at the end of the day. It is a very foolish designer indeed who will attempt to fully storyboard an animation piece for a very skilled animator because the one thing that all animators have in common is that they are all superb drawers, that's what their business is for heaven's sake! There will be other times when the need for very precise and unambiguous drawing will be required and often that will be the case even to animators or illustrators when their work is only one small ingredient in a larger cake - when you really do need to very clearly define style, colour, treatment or whatever.

I think there is a lot of work that we see today, particularly when one is dealing with high tech resources, videographic or computer graphic resources. In reality you know
there is no reason why, even in the most complex of resource areas, you cannot visualise the output. It depends on a great deal of knowledge on the part of the designer just as I guess in furniture, when you are designing a piece of furniture you have to have one hell of a knowledge about the materials, so that you know you can achieve a joint or bend or whatever. So it is with a lot of the technology that is employed in film and particularly videographic technology. You have to have a very great knowledge of the resources you are going to use in order to know what you are going to achieve. To free your mind, if you like, to stop thinking about how and only think about what. Yet at the same time, just as in any form of drawing, or the arts, if you are painting, if you are print-making, if you are painting with ceramics, with glazes and so on, then you make use of the accidents and you work with the medium itself and there is a similar need in television, to work with the medium. The one thing that the new technologies offer to the designer now is that you can actually work with the medium itself. That's quite different from designing for the medium and I make that quite clear distinction. It's interesting that many of the younger designers like to experiment and work with the technology. Sometimes the costs can legislate against it because if you are hiring resources at £1500 a day maybe, there is a limit to just how much you can go on playing.

All the designers who are used to working everything out on paper first still prefer to do precisely that, by and large. To actually use low cost, low technology, an HB pencil on a layout pad to work it all out. But the interesting thing is that the so-called high costs of the technology we use is tumbling at a rate of knots all the time so a designer can now work with a suite of equipment and have some vague idea of what he wants to achieve, maybe it's not so vague, maybe he's got dreams in his head but the tendency is more towards working with the gear rather than working with layout pads and visualising it beforehand, and maybe there is some reason to be concerned, therefore.

SWG: Does drawing on a computerised system offer the same potential as more traditional methods?

JA: Yes, of course. The Quantel Paintbox is a typical example of that, a hundred thousand quids worth of technology and if you can't draw with it, it's bugger—all use to anyone. If I put aside image-making equipment, where you make images through the use of your drawing hand and something that looks like a pencil with a bit of wire coming out the back of it, then consider all of the other technological devices that either make images or manipulate images that haven't got anything to do with the drawing hand. They have to do with software programmes and they have to do with knobs and buttons and you are working with technicians. Then the designer is sitting and saying 'this is what I want to achieve, show me' and someone's showing and you're choosing
and you could say the act of selection is an act of designing to some extent.

There are dangers that the tidal wave of technology, and believe me it is a tidal wave that is engulfing us, might well discourage people from drawing and encourage them to believe that you don't really need all that tacky stuff. We have not noticed that here. We have not noticed it because it is very much part of our recruitment policy - I would never appoint anyone who had not got very strong drawing skills. It's really rather interesting when you look at the sheer ubiquity, the sheer sameness of a lot of computer-generated imagery worldwide, this plague of flying, three-dimensional, weightless objects glinting and gleaming and turning in three-dimensional space, logotypes for banks and building societies, television titles and God knows what else. I mean it's all looking the same because the technology makes it possible. If it were possible to assemble in one place the very best work from the very best designers in this country then you would find that work very largely coming from those who have spent their formative years as designers without all that technology. Many well-known names in the game and none of them would say any differently from me because most of them originated here. Most of them have achieved their success as a result of damn good visualising skills.

SWG: Is it possible to teach that quality or is it something that is God-given - a gift which you hope to tap into?

JA: What a question. Who am I to tell you or even comment on whether something is a gift from God or not. I don't like the term 'creative' because I don't know what it means. You know we all know quite a few creative accountants and creative school-teachers and all kinds of other people. Creativity is something which designers have taken on to themselves as something which is special to them. In the advertising industry it is rife, the creative art department, the creative designer. I'm a creative designer, the word has been overused.

What is it that enables someone to draw well? God knows, I really don't. I know that one can recognise good drawing skills, good visualising skills, good communication skills through the act of drawing, however you wish to put it, at a very early age. I have two children, one is seventeen, one is fourteen. The fourteen-year-old loves music and is good at drama, very good at drama. The seventeen-year-old has no musical ear, not in real terms, not more than average and is a good writer but cannot perform on the stage awfully well. She draws excellently and has done since she was a very young child. If I look back it was quite possible to see the difference between those children when they were each three and four years old in terms of their drawing skills. I know everything seems easy in retrospect but I really mean it that way. My own kids are the only experience I have of being able to witness creativity right from
birth in both of them and one has very advanced drawing skills, observation skills particularly. They both have identical backgrounds, identical parents, their mother is an illustrator and designer. The house is filled with all the things you would expect. We have a studio at home. They both have the opportunity to work with decent materials. I say decent materials because I think it must be a terribly inhibiting factor for any child at school to be working with those powder paints and the awful paper which you get in schools, they can't experience the joy of working with nice things.

SWG: What of the functions for drawing in the wider sphere of education?

JA: Well, I think drawing assists creativity, there is no doubt about that. What I am questioning is your question about is it a God-given thing. God-given, parent-given, I don't know what it is, all I can tell you is that I've got two daughters who went until they were 11 years old to the same school, from the same background, with the same parents, coming from the same home, and one can draw exceedingly well and the other cannot. What that teaches us, I have no idea. I believe it is possible to encourage development, which is what teaching is I guess, you can encourage the development of skills, but there has got to be something there to start with and you can either suppress it and discourage or encourage. There is no doubt about that in my mind. I honestly believe that you could take anyone off the street who says 'I can't even draw a straight line' and you can prove them wrong. But there is a whole host of difference. I never knock those kind of exhibitions that one sees along river banks and in local Town Halls and so on where you get the local sort of Sunday art club and I think it is all great fun. But it is one thing to be able to put together a muddy picture and call it all your own and put it in a frame and think 'Aren't I good' and Auntie Flo says 'Isn't it lovely, it is just as I remember it' and judging things by professional standards. The interesting thing about children's work is that it is not only that naivete that we all enjoy and that simplicity, I mean I have always believed that the handling of art and design education at primary and secondary level has been appalling in this country. I know the Design Council is working very hard to correct that. I remember going to a Schools Council Conference in York in about 1971, there were two geographers from South Wales who caused the Schools Council to look closely at graphacy as they called it, 'graphacy' as it should have been called, if you are dealing with numeracy, literacy. Graphacy was something which was being entirely neglected, certainly not being taken as any core studies. Even when I was at school, a County High School, many years ago, art was two periods on a Friday afternoon and it was there for a bit of light relief.

SWG: What of art and design education now?

JA: Well I think design is changing in secondary education now, what is this new subject area called?
JA. There is nothing wrong with the concept of that method of teaching, I think it's great. The problem from what I have been able to see for myself is that there are not too many people that have had this subject thrust upon them within secondary education who really know what the hell it is about themselves. I did woodwork and art at school. In woodwork you made teapot stands and egg stands, quite literally that's what you did so you could learn how to make joints, nobody told us what a good design for a teapot stand was, nor were we encouraged to consider what were the properties that would be expected. All we knew was that a teapot stand was a crisscross piece of wood with a hexagonal piece of ply on top. There is so much you could teach, I have never been a teacher, but I've lectured. I know that in my own experience in bringing up my own kids and trying to encourage them to think in certain ways we used to play silly games. Maths, they never either of them liked maths, I used to say 'nonsense maths is not something that you do for homework, maths is in every aspect of our lives, there is nothing that you cannot say to me that I cannot prove to you that there is maths involved.' I remember saying that doing the washing up after Sunday lunch once and one of the kids said 'well there is no maths in washing up' so I said 'if I fill the bowl to the top and put all the cups and saucers in, what happens, well the water comes out doesn't it'. So we used to play games and they used to try and catch me out but if you can, it seems to me in the educational process at whatever age whether it's maths or whether it's drawing, one should encourage problem-solving and exploring.

I'll tell you one of the most awful things that happened in recent years for me here at the 'Beeb' was when the canteens went a bit up-market and we had proper tablecloths put on the tables. I think those have gone in one of the restaurants now and they are all Formica tops, but they used to be paper tablecloths and if you were sitting at a table with designers and all those things people talked about whether it was an extension they were putting on to their house, or a pair of shoes they'd bought or some idea they had about something or other or an antique candlestick they had seen down the Bush or something, it would be drawn and at the end of lunch this whole damn paper tablecloth would be simply covered in drawings not because they are vandals but simply because it is the easiest way to talk to people.

So to encourage that kind of communicative process, to go back to that earlier piece of conversation where you were asking me is there other alternatives between words and images and whatever, it's all part of the same damn thing and it's facial expression and it's body language and it's everything. Even in maths teaching there is very much more drawing. If you look at modern maths books there is an awful lot of drawing in it. The stuff that my kids use now is full of drawings and maths is about visualising, they
I was talking to someone some while ago who is a lecturer on an Engineering course at Cambridge University. We were talking about visualising skills and the ability to be able to take up an engineering idea and describe it in simple terms like describing something as being like, say, a rugby football that you might do this with and imagine this is happening. I always like sitting in those kinds of meetings where you've got designers and lots of other people because if you are in free thought during a meeting you know full well the designer is going to be able to visualise very clearly - they are looking for kind of 'primitives' in their head that they can describe situations with.

This guy from Cambridge was telling me of the requirement to assist some overseas students, and particularly from African countries, in visualising skills that were essentially European visualising skills. It is a deeply cultural thing. When I take my daughter to ballet class I'm surprised at the very few male dancers but there is a social stigma to it. In a way I've noticed that too with drawing. If you are good at drawing as a boy in certain schools, in certain situations it's identified as being not awfully masculine and again I don't know why the hell that should be but it's something that I have noticed.

We have been talking about all different kinds of drawing, communicative skills, visualising skills, but I have said little on observational drawing. Most of the designers here draw frequently. Some of them go to life classes, all of them keep sketchbooks, notebooks, when they're on holiday they fill sketchbooks etc. In this community of designers here I cannot say that if you went to every design group out there you'd find the same thing, I can only say that there is the ambience here that people do draw.

I only have the time to draw on holidays. That's when, every single one of us contemplate getting the hell out of this crazy business, none of us would be afraid of having too much time on our hands, every single one of us would say the same thing, be able to do some drawing and painting. It's too easy to say that I know but it's true and after a while you become a little concerned to expose yourself in this way, I wouldn't show anybody anything I have done in recent times, it's private, because you think it's not good enough. The problem with working in a professional capacity and with a lot of ace-pros whose work you enjoy is that if you are not doing it all of the time you become less good and yet you cannot enjoy that privilege of being less good as a result of being very young and inexperienced any more. You actually worry a little about letting anyone else see your work because you know full well they would never ever judge you again as an amateur you see, so what Auntie Flo can get away with I'm not capable of it.

We have talked a lot on the professional requirement of developing graphic skills but it goes a lot deeper than that. I can remember very little of the details of history or
geography lessons way back when I was at school, but I can remember the scenery I
painted and I can remember the little scenes I designed for the puppet plays, I can
remember all that stuff very clearly, not just have some vague memory, very sharp
images remain in my head. We are not just talking about professional skills and
drawing assisting designers in that sense. We are talking about life skills and we are
talking about those abilities which actually contribute to the totality of our lives, our
kids lives and those around us. As many other people have said 'If any country or
civilisation is remembered for anything it is remembered for its art'. That too is a cliche
but it's a truth.
Interview 3
ROYDEN AXE
Director of Concept Engineering, Austin Rover Ltd, Coventry.
Interviewed: 2.11.1987

SWG: Could we discuss your use of drawing in the development of motor cars. That is to say, I would like to explore the various roles that drawing has for you, either personally or in your organisation here.

RA: I think I should start off by explaining the kind of skills we have in this particular office. We really are, I suppose, the epitome of craft, design and technology. We have sculptural modellers and model makers; we have designers in the industrial design sense and then we have quite a lot of engineers who really are responsible for the feasibility of the design - taking the design up to a running prototype. This all happens within this area, which is quite an interesting spread. Now the drawing in the engineering sense, if I can just briefly deal with that, is dealt with by computer these days to the point where the physical drawing is not produced very much. We still do some of it, because we simply have not had the ability to get all of it onto the computer programmes. We are progressively doing that and it will not be long before virtually everything is produced as electronic data. I will come back to that because it is not quite so cut and dried as that.

Now there is a bit in the middle which is the creative design and shape of the car that is not computerised and we cannot see any way of it being so in the immediate future. There simply is no computer programme that can cope with someone illustrating forms in space and then converting them into data in a machine. It has to go through some process of modelling in order for that to be done. So the designers, those who really deal in the traditional skills of illustrating their feelings on paper, do so by what I describe as 'caricatures'. They have to sketch, very realistically, the forms and shapes they are after on a car design but at the same time have to do a great deal of 'caricaturising' in terms of exaggerating certain features in order to get the point of the design or the impact of the design across. In years gone by sketches formed the basis of the presentation to the Board and the choice for the car design was made from those sketches, but this is no longer the case, certainly not in this office anyway. I am really the most senior person they need to go to with the sketch. Interestingly enough, we don't show our Board anything but a fully finished fibre glass model which is totally and utterly realistic because these people cannot use their imagination. That is the way we approach the sketch and the drawing part. Drawing is an extremely important skill as far as I am concerned so I am very sad to see the standard of drawing in education.

Appendix I NSEAD project transcripts Royden Axe A20
falling off.

SWG: Referring to the engineers and not just the stylists, do you encourage people with technical ability to communicate by drawing before they go on to computers or even whilst they are on the computer?

RA: Well, they do not really need to now. There are two main reasons for conversion to computers in this office. First of all there is what I call 'packaging' work and that is assembly of the components, including people, into a package around which the designer can design. That is something which is obviously very adaptable to computer screening because you are dealing with objects, be it human figures or an engine and transmission or whatever and you can juggle them around on a computer screen perfectly. Drawing, which used to be the way we did it, was obviously an incredibly laborious prospect. Once you move something the knock-on effect is unbelievable. It takes days to do these sorts of things. Also there were some drawings such as orthographic projection type drawings of complex packaging problems that were virtually impossible to do. I mean you literally could not find out where you were, they were so complex. The computer will separate all that out and make it very, very easy to do.

The other application is when we have a clay model completed and we wish to define the surface of that model electronically. That is an interesting process because there are two ways of doing it. One is to define it in a mathematical sense in which case it might not be quite the same as the designers intend because the machine has smoothed out some areas which the designers may not want to smooth out. They may want a little bit of imperfection in there. In fact our system allows that imperfection. It may be a bit more laborious but it does allow the operator, the engineer, to faithfully reproduce what the model says. When we put these systems in, the surfacing system, we had two types of engineers working the machines. We had first of all the traditional layout draughtsmen, these are the people who have learnt to draw on the drawing board and they have produced full-size draughts of the car. We also have quite a few computer engineers, engineers who were trained in the working of the computer and who were needed to operate it. Now we needed the two initially because the traditional body engineers simply did not know how the machine worked and the other people were at least able to show them that. Once they got the hang of it, however, they far outstripped the computer engineers because they saw the way of applying the computer programmes to their experience of drawing a body draught which the computer engineer had no knowledge of. I mean when it came to putting in a fill-in radius or blend radii and things like that the computer guy was completely lost and it was the traditional draughtsman who was able to interpret how the machine could do that type of work. There was a very good interface and what has happened is that over the last
three to four years the computer engineer has faded away and is now in a sort of advisory capacity on the technicalities of the machine and the dominant party is the old draughtsman, as it were, who is converted now. What is interesting to me is what happens in this next generation because we now have a lot of young people who have never been on a manual drawing board and never will. We are saying how will we get those people up to speed. Perhaps in the early stages they will gain experience from the older hands but they will not have experienced drawing.

SWG: Would it be an advantage for these young people to undertake some sort of drawing skills, both technical skills and freehand drawing skills?

RA: I think an analogy to that is - 'do you learn your ten times table if you are to operate a computer?', and the answer to that is obviously 'yes, you have got to'. I strongly believe there are basic skills you must get and understand before you can use these machines to full effect so I feel very, very strongly indeed that we need to have those practical basic beginnings.

SWG: So you mean by that you need to develop both the technical and the freehand sketching?

RA: It depends on the individual. I mean it depends on what field he is in. I do not think one of these individuals needs to have both although I am very, very strong on bringing both the engineer and the industrial designer together so they understand each others skills and understand the complementary nature of them because I do not like them being separated.

SWG: I have been looking at the work of Sir Alec Issigonis and particularly his drawings. Obviously he was a very good engineer, and yet he was able to communicate and manipulate through sketching. Do you think there is still a role for that sort of person?

RA: Absolutely, I would anticipate that any engineer worth his salt would sketch away like that. It is a different kind of drawing. It is a sort of freehand engineering drawing and I would like to feel that any engineer in his thinking process would use those techniques, I know most of my best people do. They have a little sketch pad and they will do things like that and they will doodle around often before they go on the screen, which is interesting.

SWG: Have you found in your experience that engineers have lacked that ability or is it a more recent phenomenon?
RA: I think it's beginning to show. I don't think they have in the past because the basic skill they required to do their job was the drawing skill. Now there were two things which caused problems, one was the educational system putting less emphasis on these drawing skills and the fading away of what I call the traditional apprenticeship scheme which literally put people's noses to the drawing board for a couple of years. So, that is one problem of the fading away which is purely educational and the second one of course is that they are simply not called upon when they join industry to do that and therefore in many cases a person might be hired for his technical ability on a computer. Those are the two reasons we have drifted away.

I am very concerned at the moment regarding my involvement with education. A major problem to me in training aesthetic designers is that I am setting people who have done a four-year degree course and a two-year post-graduate course in industrial design transportation who don't really know how a car works in all that time. I mean, you would think in six years you could squeeze something in which would show them how it works. What we do when we have seconded students into the department for the summer vacation we actually put them into our car plants. What we say is that rather than do a repeat of what you do at college and work in our studio, go out there and find out what it is all about. I think that something like that with drawing might prove to be essential in the future. We may have to set up, if you like, a small training drawing office so that we can feed these people through it before we put them onto the computers as they graduate. They won't like that because students who graduate tend to think they know it, don't they, so it is going to be a little hard to say 'you have to go back to the beginning', some of them may not be able to do it which is even more disturbing.

SWG: You talked about modelling earlier on. I believe that the relationship between drawing and modelling is quite profound in the creation and development of ideas. To what extent do you use modelling activity?

RA: I believe the designer thinks very definitely in three dimensions. The only reason you go through a two-dimensional phase with him is because the process of producing a three-dimensional model is extremely cumbersome, time-consuming and labour-consuming. Therefore you are asking him to go through a lot of his first iterations two-dimensionally, very easily. He can get those out of the way and settle on what he really wants to do before getting down to the model. So you have got to hold back your resource, if you like, on modelling until you have got something really serious you want to do and then you can use it. Three dimensions are the all-important thing. It is always very painfully obvious with design students of a few years ago that there wasn't the same emphasis, in design education, on three dimensions as there now is. They really had a great deal of difficulty when they came into industry in actually
getting into that three dimensional mode. The sketch didn't work out in three dimensions and they didn't understand why. Often they were good illustrators, but I think there is a big difference between an illustration and a design. That is what you are looking for with the two dimensional skills of design, you are looking for the means to illustrate a design, and then go into 3D. So 3D is an extremely important part of our operation. We put a heavy emphasis on it, we employ a lot of clay modellers, we employ a lot of model makers, we have a full-blown fibre-glass shop which turns out a large number of fibreglass models every year. We also have, in fact, other ways of producing three-dimensional objects within the studio. We have got a very strong dependence on three-dimensional models and as I said right at the beginning, only the three-dimensional object is shown at the end of the day and it is a very highly representative object.

SWG: Do you think in your industry the clay or fibre-glass model has replaced the drawing. I know it has always been important for the last 30 or 40 years but have you seen a decline in the slick felt-pen renderings?

RA: No, as I said a moment ago, the felt-pen renderings are the germs of the idea and you've got to have a lot of that done before you select what goes into 3D. What is so difficult to do is the three dimensional representation. When it is complete it has to be totally feasible as a car so it's not just a picture. It has to be a very detailed and accurate representation of the car and to get into that you have got to have a very clear idea of what you want to do because it is no good going in, hoping everything will work all right, because it doesn't. There is a lot of two-dimensional felt-tip work that goes on.

SWG: Do you employ a number of people to give you those ideas, for example employing Italian stylists, or is it all in-house?

RA: No we don't mind doing that in the general sense but if you go to an Italian designer he has his own house-style, if you like. After all that is what you go to him for. Now, I could sit down, I think, with my thirty years in this business and sketch what I would get from any one of those designers. In fact the biggest danger is that they do sell designs to different people, I think there is more of an emphasis on developing a Company style. I think in that sense we keep a very good dialogue going with the Italian people. I know them all. We talk very frequently. We have put work with them but we don't do it very heavily. If I really felt I was bogged down on something I wouldn't hesitate to get another viewpoint but I would be very cautious as to who I chose to do it. I would be very careful that the brief didn't hold him down too strongly and that he would give another viewpoint.
We have a complex range, changing all the time so there is always creative work going on, and at very high pressure too. There are all kinds of problems really in going to other outside operations. Let me explain to you what used to happen years ago when design seemed to be part of engineering, rather than an independent thing, such as it is now. Usually the designers were left to clean up the mess as it were at the end of the day. The engineer would engineer the product for pure engineering reasons without any aesthetic considerations at all, and then there would be all sorts of panic. Perhaps people wouldn't like the look of it after all, and designers would be brought in or stylists would be then called and they had to tidy the thing up and more or less get it sorted out. The designers were not given any chance to influence some of the basic packaging which affects appearance, proportion and the like.

Therefore, very often the Board of the Company would get what they considered, quite rightly, to be very unsatisfactory results. Then they would go to an outside consultant and they would give them a free brief and that consultant would really, when he had done it, just wheel the car in at the end of the day and the Board would think that was just great. Now he had probably changed quite a lot of fundamental things which was forgotten because the car looked so good. They could do that with the outside person, but the inside person was constricted. Now things have radically changed in the last few years and in an office like this, for example, I get very little interference from the Board at all. My job is to design the cars and I am left to do it. This means we can bring engineers and designers together and get the best compromises between the requirements. They all work together extremely well if you bring them together. This constant confrontation between designers and engineers melts away once you get them together. It is largely a question of getting everyone to understand what they are about, everyone is complementary and it works well.

SWG: They evidently can't reproduce each others skills but they are sensitive to each others contributions.

RA: Exactly, well they understand what the other person is doing. There is always a feeling amongst the designers that the engineers are bogged down with dimensions and details and analytical things which will bring about very stodgy results. They don't understand that isn't really what the public is excited about. The public is motivated by the desirability of the car, there is no doubt about that. The engineers on the other hand consider the designers to be totally impractical beings who don't care so long as they get a nice looking car or if they can't get anybody in it. If you keep them apart there is this traditional animosity and suspicion. If you bring them together, around the model as it is developing, everybody understands everybody else's problem - it is miraculous.
SWG: So how does your design office operate and how does it bring them together because it must be a huge operation?

RA: Well, to bring the cars up to the first stage of the prototype we employ something like 300 people. A number of those are seconded from engineering who are responsible for taking the finished prototype design to its production and that does involve something like 1500 people, but those 1500 people are ensuring that that design gets into production. The 300 people at the beginning, which includes some of these people, are the ones that are really responsible for the design and the creation of the car. In industry terms 300 people is not a large number. General Motors in the United States has probably about 2000 on that kind of thing. In fact you are better off with 300 than with 2000 because it makes a much tighter field. How we do it is that we have a central core, a central large room in which the models take form and in which all the designers are permanently located. Then we have around it various shops for fibre glass working, woodworking, for specific engineering tasks, etc. They are located on the fringe including places for our suppliers because they bring their goods in and work with us. We bring everybody together as they are needed.

SWG: The model is obviously a catalyst for communication - the designers and engineers can go and refer to it. What role does drawing play in these groups communicating and developing that one concept?

RA: There isn't a lot basically between the engineer and the designer in terms of sketching because at that time there is a package produced by the engineer and that is the skeleton of the car as I described earlier. The designer is loosely working around that but he isn't letting it inhibit him too much. He is exploring what might be wrong proportionally with the package and what might be improved and he is also, as I said, caricaturising his shapes. Very often his sketch to the uneducated eye doesn't bear much relationship perhaps to the package on which he knows he is designing and it takes another designer, perhaps myself, to make the final choice and to say 'yes, I can see that design will work although it doesn't look like that package there. I know what you are trying to do, right we will take that into three dimensions'. There is an interaction between the packaging engineer and the designer. Now once we've got that sketch, that caricature, it is the basis of a programme of sketching which is the basis of the model. Then we put the designer who created that particular design together with his team of modellers, there are probably five or six modellers in that particular case, and we set about making a full size model of that particular design. To do that, it really is a very strong interaction between the designer and the modeller. They together really, define the shapes in the final form on the model around all the restrictions that are going on in terms of the practicality of what they are putting together. Then all the engineers are involved along with manufacturing people and cost people because the
final model has to be right in every way. That model is accurate to about half a millimetre and it is intended as a perfect representation of what the car will be.

SWG: How do you see that creative process developing in the next twenty to fifty years? Will it remain the same?

RA: No I think it is going to change quite radically. I think the first step is going to be some kind of ability to take data directly from sketches to enable us to make a model by other means than the manual method we use now. We have just invested two million pounds in a five axis milling machine which is computer driven with data from the surfacing of our models. When we build a clay model we surface it - we develop the surfaces, we feed that data into our five axis machine and produce an exact replica. Now that machine is therefore doing away with a lot of the more mundane modelling tasks. So where we had a very large modelling group, of which perhaps a third is what I would call the creative/sculptural modellers who work very closely with the designer, the other two-thirds were proving out things. They were taking the finished data or drawing and they were converting it back into a model so we could see whether it was right. Now that machine is doing that for us now, more and more. Therefore that large group of modellers will be transformed into a much smaller and more specialised group. It changes the emphasis of our modelling task completely. We also feel that there are a lot of interior components now. If I use the example of the inside of a windshield cover, it is bounded on one side by the windshield and on the other side by the door glass. This form is further complicated by the way it touches down on the fascia and the way it joins up with the roof lining while the section of it dictated by structure and legislation - there is the structural problem of the strength and there is the legislation problem of the vision angle.

All of those problems are an ideal task for the computer to work out because they are very complex problems. The computer can wireframe the thing, it can develop the surface and we can then convert it into a shaded drawing on the computer. It will show you the picture. The computer will generate the light source and so the designer will see what he has got - he can design components like that right on the computer. We are just starting to do that, we have not done much yet. He can get a shaded drawing on the screen and he can say "yes that looks right". He can press his buttons, the five axis machine makes it, and there is his bit without any further modelling so if you extrapolate that right through to virtually the whole car you can see how progressively we can do more and more.

If you talk to designers about computers they become very excited. The computer is the way of the future, the thing therefore a designer should be into. They get very excited about it, it's wonderful. But then they are confronted by a keyboard and even if
it is a sketch tablet and a light pen, still it is not right, it is not how they can express themselves and they have extreme difficulty in doing so. Industrial designers are not as analytical and they are not as numerate in some ways. They do not seem to have the ability to work keyboards and the like that their engineering colleagues do and therefore they are dealing with an alien machine. In my opinion it will require the use of holograms to overcome this. I really do, I think that is the only thing that is going to enable them to do it. Until that happens we are not going to make any major progress. Probably if you are talking twenty years from now I would be fairly confident that we will be dealing with full-size holograms by that time and we will be able to develop the car before our very eyes, as it were, without it really being there. We would be able to walk round it, we would be able to look at it, we would be able to ghost-in the internal components and make sure that everything fits, we would be able to have the engineer and the designer working together. It will all come together I think in that period. It will take at least twenty years, I believe, talking to a number of computer people around, and you will end up with individuals who will be very capable of putting the whole car together. The interesting question therefore is how many assistants will they need? Very, very few I suspect. If you take that a stage further and you say that into that system, that core system to design a car, you can link in virtually every one of the Company's other systems, for example you can link in a product cost system which would effectively analyse each component as it appeared as part of the design, you could have almost an instant analysis of what you are doing cost-wise. It immediately changes the whole role of the cost man and again you need very few of them. It's all linked together, the financial system, market research and design one or two people are going to be able to do a hell of a lot.

SWG: Obviously creativity is going to be a very important asset - the human quality which you are going to need in that much smaller environment. How do you envisage education should address the problem in developing creativity?

RA: It's very tough to really know. The education people have been in this office frequently. H.M. Inspectorate in particular has spent a lot of time with us at various times and they have said "well, what do you need, what should we be doing," and I say I'm damned if I know. Unfortunately, we are only going to need a very small number of the cream of the people and that really does not present any problem to me. It is very easy to cream off the top few people and if we need fewer it is going to be easier.

The big problem is what do you do with the rest of them. I don't want them and I am not going to need them, therefore what do you do? Where do you channel those people into different kinds of creativity. I think we have got to look at the big industries who have traditionally not exploited creative potential and small scale concerns who depend
on that asset.

SWG: I would argue that drawing was an excellent way of developing both an appreciation of form and the conceptual skills of designing. How do you think education should approach this issue?

RA: I am with you 100%. I think that it is very important. I was reading this research outline you sent me, some of the comments that were made in it were absolutely right. On this particular page you refer to Colin Tipping’s quote about ‘sketching ability is the single most important factor in developing any general design ability’. I agree with that.

What worries me the most is that even in Art Colleges the biggest single comment made by my people when they go into these colleges to work is that there is hardly anybody in these colleges who has the basic drawing skills to be able to pass it on to their students. In fact I have a son in industrial design college at the moment and he has had extreme difficulty finding anyone who can help him. It was only recently when he did six months industrial placement in the United States that he got any help to do this. To actually be able to draw. Now, American colleges are very heavy on that, I did many years in the United States and my son was actually educated in the United States. There you could always be sure if you employed a designer from any of the recognised Art Colleges in the United States, the one thing you knew they could do was draw. There would be very few that would slip through the net that did not have a well developed ability. In England I rarely see that ability in Colleges, very rarely, there do not seem to be many lecturers who are employed full-time in colleges who have that real ability. Most of this, I think, is because a lot of them have never worked in an industrial situation although that shouldn’t be a problem. I mean if they had been educated in the art of drawing they should be able to do it. They cannot. I think there is nothing worse than a student who is struggling with his work and he has to wait a week until someone comes from industry to actually straighten him out and show him how to do it. That is how it is.

SWG: I think it is particularly bad in the university sector where they rarely even value it, let alone exploit it.

RA: That is exactly right, Universities and the engineering field, as you quite rightly point out, it is just not part of their thinking at all.
SWG: Could you tell me something about the nature of your work and what you try to do here at the school?

IB: The earliest processes start before the students come to the school. We would like to think that the students who apply for the Architecture course already have some knowledge of what it is they are applying for. That is, they should have in themselves a range of interests which cannot be described merely as intellectual, intuitional, aesthetic or emotional but they in fact cover a broad band. The whole process of educating young architects really starts in obtaining the right people. If I could draw an analogy, you know yourself that the solutions to problems are really much less important than problem definition in that if you define the problem incorrectly, you are never going to arrive at the right solution. So it is axiomatic that a good solution, a solution which satisfies the magical formula of form and content, consists first of all of a very accurate definition of what that content might actually be in the broadest possible sense of the word. In context in terms of social value, the materials which might be used and the means of production.

SWG: Would you go so far as to say that design is more a question-asking process than a question-answering process?

IB: Yes, very much so. From long experience I do know that the solution and the problem stand magically alongside each other. The whole process of drawing is to do with identifying very clearly what the problem actually is. The young students must be interested in organisation and management, in administration, in means of production. In point of fact they are actually interested in producing something that is not a drawing. If I could produce another analogy, a composer who is either composing in his mind or composing by rapport with a piano, is not in fact primarily interested in the means of production. It is the end product which is calling his mind all the time. His musical manuscript, which is similar to an architect twiddling around with pencils and models and so forth, is a means of entry into that magical world which he knows at the end will be a musical composition.

So a student has to be very vividly aware of the fact that drawing and model-making and conceptualising and experiential things of that sort are working towards an end and...
at that end is a substantial thing which has social and aesthetic value and technical credibility. In recent times architects workloads have been rather slack and there has arisen a period of retrenchment in which the architect has taken time to watch what the point of his pencil is actually doing. This is in contrast to the very busy years immediately after the War when I was in practice and architects were technically involved. A great many of these essential values that I have been speaking of were totally forgotten about, technique was all that was important, cost, technique, production programmes, management, getting things up, social and cultural values were largely forgotten, and that was a disaster. Now a little pause has taken place and that has allowed, or even encouraged, architects to stop and think a little bit again about what the thinking process is between their inner eye as Wordsworth would have said and the externalisation of their thought. Unfortunately it has gone to extremes in some cases. Those architects who have no work to do have become heavily involved in the theory or semantics of architecture and have spent a great deal of time producing very beguiling drawings which are very nice, but going back to what I originally said they have become ends in themselves and students can become overly influenced by that, they can become overly influenced by the beguiling image that someone has drawn. I am not a musician, but I have a collection of scores which I like to look at. I can't read them, I am not musical, I don't have the language of music, but I can look at them and I can tell immediately that this must sound great because it looks great. Now that's not a trap for me because I am older, but for a young student it can be a trap, he looks at the beguiling drawing and sees it as a means to an end. This school is concerned with the formulation of young minds to understand that they live in a three-dimensional world that is occupied by people and that primarily, whatever we may think about the world philosophically or scientifically, it is the human occupation of time and space that is really our problem. Our work is concerned with individuals and it is concerned with the collective society. It is therefore concerned with emotional and physical and social context and it is concerned with the means of expression of those contexts and that is what drawing and model making is all about. It is a research process towards an end. In architecture and in other disciplines, drawings vary hugely from empirical sketches, schema sketches or thumbnail sketches, right through a process to a very elegant production or working drawing. I teach a course on this particular subject and I try to impress upon the students the enormous importance of seeing the end in the beginning, and in the end seeing the beginning from which it came. It is T.S.Eliott's famous quotation, "We will not cease from exploration and the end of that exploration will be to return to the place from which we started and recognise it for the first time." It's this great circularity, that you don't keep going forward, you keep going back and forward.

Drawings to an architect I see as being absolutely sacrosanct in terms of their integrity. They should be as exact and precise as a flautist fingering his instrument. You can actually become extremely passionate about the accuracy of your production drawings.
provided they are well founded on very good and interesting ideas which they are expressing in a technical manner. However, they are expressing ideas which are not essentially technical, that's the means of production, what they are actually expressing is the finished experience just as a sheet of music is expressed for an audience through interpretation by skilled instrumentalists.

SWG: The essential function of production drawings is to communicate. What other functions can drawing have?

IB: I think the essential nature of the thumbnail sketch is it gives rise to free discourse because it is by definition not a complete object. It is a search object, it can therefore be created and de-created very quickly and that is the essence of it, to prevent a student from crystallising too quickly. You can do a great deal very quickly. There are some students who find it quite difficult to express themselves but nevertheless they may have very fine thoughts. Getting the students to come out of their mental shell and not to be afraid of making mistakes, that is the essential thing, just as with an experiment in a Science Lab, you may learn as much by doing it incorrectly and finding that the thing cannot be done as it is in finding out it can be done. It is very nice to find out that what you thought was right, but it is equally valuable to find out that what you thought was wrong. Instilling in the student the idea that what he must find is his own personal expression is very important. He may be a bit ham-fisted to begin with, in knowing how to express himself, but that is not ultimately important, because that is part of the process. What is important is that he should understand very carefully his own limitations and his need to recognise and to analyse his own problems in relation to the major problem - the thing which he is addressing. He has to find out and devise methods of thinking and methods of designing which will in fact arrive at the product.

There are many architectural firms who do not search for form in the means of drawings. Alvar Aalto, for example, did very, very sketchy, embryonic, schematic drawings which were purposely ethereal because he was trying to catch what you could only call the 'spirit' or the 'essence' of the job. He did not wish to compromise solution by seizing on form too quickly. The process of the search for form was much, much more important. In modern times Utzon is very similar. If you look at his drawings they are very, very ethereal, just a little sketch, an idea, a schema. Aalto, after that, developed all his schemes through models not through drawings. Then what they literally did was draw the models as working drawings, Lasdun in the modern era does that too. When he was looking for the form for the Southbank complex, which is rather controversial, he said that his office was actually filled with models and he had to clear people out of the rooms in order to get more models in.

SWG: Do you view drawing as two dimensional modelling?

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IB: Yes in many ways it is. Drawing and making and understanding. It's a quick and convenient externalisation of the thought process. What all students desire to do, because they admire perspectives, they want to very quickly attain a facility for perspectives. Strangely enough the Mackintosh School has not encouraged perspective drawing. You will find a distinct lack of perspective drawing in the Mackintosh School because, I think, they are overly beguiling. They are rather like cartoons of buildings, they can take significant bits of the building and overemphasise it, they can play down other parts of the building which actually ought to be more carefully referenced, identified and studied. Basically our work in the school involves orthographic drawing projected into three-dimensional thinking by means of models and computer work and also by axonometric and other types of isometric graphics. These are much more important to us than perspectives which we see as a P.R. job rather than a real explanation of what the building is about. It has gone into the area of selling, it has left the area of real study. I am not attacking perspectives for lacking in integrity but I think as part of the design process you are in danger of getting into an area of falseness where the image is not really what you are out to find.

SWG: What is the relationship between learning accepted drawing skills and developing a personal, graphic, designing ability?

IB: Each person has got to find his own way of doing it. Aalto found his own way of doing it, at what point in his life he found it I don't know, we all find the creative truth within ourselves at different stages in our lives. Some students are fortunate enough to find it relatively early, other students don't find it until perhaps many years later. As human beings we are highly sentient creatures and our emotions and feelings are far more important than our intellect, particularly as creative people. The triggers of intellect are recognisable but the triggers of emotion are not so recognisable, much more to do with serendipity. That would be one of the fundamental reasons why Alto and certainly the Mackintosh School would try to inculcate in a student that the beginnings of form making are not of a technical nature. The technology in fact responds to the feeling. There is a very good story which I tell to my students. I like to use analogy and I do it because architecture is a kind of priesthood and young people don't always which understand the language of architecture. This is another thing these chaps who have no work to do have invented, a whole language of semantics of architecture which nobody understands. It is a bit like reading theatre criticism - you wonder if you have been at the same play!

Anyway, analogy. Liszt was a very great piano-teacher, he was one of the greatest composers, pianist, and teacher of that particular instrument and a great many young people went to him for tuition in master classes. He always used to ask them, "what is it you wish me to teach you" and he said that he got a very large number of answers.
The common answer was “we wish to learn something of your technique” and he said “well in that case I cannot help you because technique flows from the soul and my technique flows from my spiritual appreciation of the music. The spiritual appreciation of the music comes first, not the technique. If it is technique you wish to learn then you will have to go and learn that from someone else.” That should be the way to put it in architecture or in any field. Who was who said “A great idea deserves a great technology and begets a great technology”?

The great example of this in our time is the Sidney Opera House competition by Utzon. Utzon is a highly sensitive, emotional architect who has considerable technical expertise but he does not pretend to be an engineer. He is a first-class conceptualiser of architecture and design in its broadest possible sense. I have already quoted him as being one of those people who draws images and nothing more than the image. He then requires those people who are concerned with technology that they should step out of their own skulls almost, certainly over the frontier of what they already know, in order to achieve what his mind has expressed to him. Utzon’s ability resulted from long experience but he also worked through gnostic principles, where if it is felt to be right then it is right. It is my prerogative as an artist to say that I do feel it is possible and that is why someone like Utzon would never give up until the forces of conservatism were so arrayed against him as in Australia, that it eventually broke his spirit and he gave up. Someone like Kahn would not have had his spirit broken he would have insisted right to the bitter end. He would have stuck with his project, he would have forced the technological people, forced the administrative people, forced the political people to bend to his poetic will during his lifetime. You see we all bend to poetic will ultimately, the problem is doing it in the lifetime of the person who is actually giving us the message. This is why so many poets, so many musicians, so many artists, so many architects are not powerful influences in their lifetime because they are so far ahead, culturally, intellectually and in every other way, that it takes time for the ordinary milieu of life to actually come to them.

SWG: In what particular ways does drawing assist designing activity?

IB: The path between the identification of the problem and the solution is not a straight line. It is an endlessly looping curve and the profile for a maturing designer is curved with change. A young student coming into the school is always looking back, getting a little bit forward, looking back, perhaps even going further back in order to get forward again. But with the maturation of the design process, as with the poet who no longer has to search for words, the words offer themselves to his mind to express his emotions then these problems I think become smaller and in many cases they might actually even disappear. So that problem identification and solution become almost instantaneous in some mature design minds. They would in fact learn to hold back, to
hold the problem in suspension and to allow nothing to crystallise at all until they felt that the moment had come for precipitation and that would be maybe a straight line from problem identification to solution. A young student always has an ambivalence in his mind. He is not only looking for a reasonable solution to the problem, he is also looking to pass the course, he is looking to get a good mark, and it is necessary for us to reassure the student that process is more important in the earlier days than finished products. A project might receive a high rating for integrity of approach but which, because of time or some other factor, did not allow him to express his ideas as eloquently as he otherwise might have done. We try to reassure him that that another student who simply rushes something out in order to get it done is not to be seen as being more credit-worthy because he has done the job. Assessment should involve the examination of all the students work, put together in a portfolio, at the end of a session. At that point some kind of final, collective, holistic assessment would be made of the progress of the student. Not a series of marks, one of which would be so bad it would arrest him for the rest of the year.

SWG: Architects appear to be far more verbally articulate about their profession than other design disciplines. Should designers rely upon their graphic language only?

IB: Wittgenstein said "the limits of my comprehension of the world are limited by my language", which is very true because if you think back in your life you will find that you cannot remember anything that happened to you before you could speak. With most of us our memories go back to the point where we could actually articulate in our language the experiences and therefore begin to register them. Almost everything that happens to us beyond our language we actually forget, so comprehension is what we are after. It is not merely being able to use the language simply in order to say I am not dumb, I can use language, it's about comprehension. Wittgenstein may have said that there is a point where language ceases to be able to express. There are no words which can adequately express some emotions. Drawing is a form of language as well, it is a form of communication. The form of communication which the architect has to articulate is immensely complex. There are many, many complexities involved in the thinking process about how a new building or a new environment might take its total place successfully in the human scheme of things. What that thing must not be is complicated. Complication is not allowable in art, it is not allowable in poetry, it is not allowable in literature, it is not allowable in any graphic form, complexity is the thing. Complexity is essential in order to enrich the experience but it is not done on the basis of complication. The method by which you teach students is through problem identification, not simplification. Everything must be reduced to its simplest, but not simpler than that. Lying within that simplicity there is a clarity of statement of a number of complex issues which are reduced to simple phraseology, both in terms of the spoken word in communication and ultimately in terms of the drawing and the

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actual spatial experience itself. But that thing must not be complicated. If it is complicated it is not acceptable to the human mind and quite rightly so.

SWG: To return to Wittgenstein's definition of language, do you think he might include graphic language as a valid extension of natural language?

IB: Yes he would, I am fairly sure. There have been philosophical artists who have tried to express that. I am sure that Klee did express it but there is a limit to what language can say for the artist, for the graphic mind, and that the next step has to be made in another way, in another form. The musician would say that for him the world is expressed through the art of sound, and the poet would say that it is done through the art of sound and through the art of language.

I think that one of the great optimistic occurrences in the world is the way in which all the sciences and all the arts of the world are coming together to recognise that somewhere lying underneath, is the rhythm of the universe, the music of the spheres. This has been referred to throughout recorded history by artists, by scientists, by agnostic people and by religion and it is becoming more and more widely accepted. It is interesting to see poetic words being used by physicists who talk about charmed Quarks, they are lost for language, they have to find an elegant equation in mathematics. I said earlier that I know my sheet music is good because it looks good. How can a thing look like good music? Well it must be that there is a factor which is not known to me, maybe not known to many people, maybe not known to any of us but it is a part of that truth to which we are all aspiring and searching for and as long as man exists as a species he will by definition be searching that 'truth' and 'reason'.
CLIFFORD BOWEN
Sculptor, Glasgow School of Art.
Interviewed: 14.8.1987

SWG: As a sculptor, what does drawing do for you? What is the relationship between the activities of sculpting and drawing?

CB: It has a number of relationships. It depends very much upon states of development of the work and very often on how familiar I am with considering certain ideas and notions. For instance it might have a different function if I haven't managed to produce any work for a while, which is often the case in teaching, as opposed to say my experience of almost exactly a year ago when I was on sabbatical leave and by this time I had been working throughout the summer and had got some momentum going. Then drawing began to take on a different kind of function but I still can't say what that function is.

I tend to use drawing very much as a means of working towards a piece of sculpture, a way of assimilating information, a way of turning over that information if it is very fresh. It is a way of trying things out and sometimes a way of consolidating a theme or a thought or even an emotional kind of sense. In some way consolidating before beginning a piece of sculpture. That doesn't mean to say that designing a sculpture is going to look like this drawing but it is a kind of homing-in and finding a direction but in such a way that it will allow the sculpture to grow itself and develop. It's very difficult for a sculpture not to grow and develop if you approach it in a certain kind of way. Some sculptors, and I say some, tend to make sculpture which is a single point of view rather like a painting or a life-drawing, which is slightly different.

SWG: Do you view drawing as modelling and what relationship is there between drawing in three dimensions or sketch modelling and drawing in two dimensions?

CB: Yes I think it is possible to argue that it is a similar kind of activity. Drawing, unless it is to do with drawing for drawing's sake, concerns thinking in relation to something that is going to be made, whether it is a sculpture or a chair or whatever. It is still very much a propositional stage and I think quite largely conceptual as well. A drawing is never going to be a finished object and unfortunately far too much design is seen as that - a drawing that is lifted off a page and made into three dimensions, but that is another argument.
SWG: Do you prefer to work through drawing as a means of sensitising yourself to the issues or would you prefer to get involved in materials?

CB: I prefer to get involved in materials. The reason why I get involved in drawing is, by and large, training. It is a habit of training. Also partially because it is very expedient to draw. One can turn over ideas and that sort of thing much more quickly in drawing, one can make propositions to oneself, if you like, you know and one can generally test notions and also anticipate problems in drawing, that is in the three dimensional form of drawing and so it can be an expedient thing to do, although if I had I suppose real choice, and that would mean if I was making all the time, I could imagine the position where drawing would play less and less of a part.

SWG: Is it simply a matter of experience?

CB: No, I think - or I hope, that my ability is a natural ability that has been there before I thought of myself as being an artist as a separate member of society. I have always made things for as long as I can remember; as a very small child, I certainly made before I drew, so it is a natural thing to do and I think it is only Art School training that put me into a conceptual mood which I find interesting and fascinating sometimes.

SWG: Does your drawing or mark-making, for want of a better term, perform important communicative functions or do you use a personal, scribbled shorthand?

CB: I do that when I find it necessary. I don't do that kind of thing habitually although I recognise precisely what you are talking about. Certainly a lot of my students do that and not only the students, I have noticed it is something a lot of people do require to do. I use it particularly if I am starting something very fresh and I need to just go over it very quickly. Generally speaking I tend to do drawings which are ostensibly for myself in that they are communicating about idea in that very close and private way of artists, but I have always got a sense of there being another person looking over my shoulder who is also going to have to look at it. I try to blend these things together, it is much more controlled. don't know whether that again is habit but I do find it useful for me. I manage to keep flipping between a subjective way of working and an objective way of working.

SWG: As a designer rather than a sculptor the work of Moore and Giacometti has interested me with regard to this research. Do you use drawing as they do?

CB: Well, I would be closer to Moore than to Giacometti. Giacometti is quite a
good example for your question about modelling as drawing. He does use modelling like drawing, although it is still to do with spatial notions, form and multiplicity of space. I would be more concerned with organising the surface very directly as opposed to keeping it flexible in the way that Giacometti does. I tend, I suppose more than anything, to hint at three-dimensionality rather than trying to consolidate it in drawing. I tend to do drawings which are very linear and have flexibility, drawings which can be interpreted in a number of ways. Where necessary they indicate a sense of form but it is not a really a tight or heavily controlled form. Drawing is only a way of getting towards sculpture and allowing the maximum freedom in the sculpture, not to determine too much before. Oddly enough many people have said to me that my drawings look very much like the sculpture, but I think they tend to naturally say that.

SWG: Let's turn to another facet of your activities now, that is, your teaching at Glasgow School of Art. It seems that you have highlighted certain aspects of designing activity that need not refer to drawing as such. How do you approach the area of drawing in your teaching?

CB: Within education you are dealing with a great variety of students and therefore a great variety of sensibilities and methodologies - how you begin with a notion or how you might find a notion to work with or how you might direct or develop your work and evolve for yourself a working process. This is to do with the student and how well it enables him or her to become a creative person. There are as many ways of doing it as there are students but they all mix and are, one could say, composed of the same sort of components. For some students it may be more appropriate to draw and for other students it may be more appropriate to make but I think, educationally, one has to give every student the kind of opportunity to find a mix of each for themselves. Particularly if someone is a designer, it's seems to me perhaps a necessary attribute to be able to draw and propose notions through drawing because again they are expedient and people understand them as a language and almost all expect them.

SWG: Do you view your work as a questioning activity as much as an answering activity?

CB: Oh yes, I see all fine art as a questioning activity. It's just a constant questioning activity and there are no given answers, this is why all creative activity is so challenging, so draining and so rewarding. Once it stops becoming a questioning activity it ceases to be creative.

SWG: What is the relationship between questioning and drawing? Can drawing replace natural language?
CB: If you are talking about using drawing as opposed to words I think that is perfectly understandable if one is trying to have a discussion about notions which are to do with the kinds of creativity which goes on when you are drawing, or the kind of creativity when you are making, or painting, or sculpture, or design. Since the ultimate communicative language is not a verbal one, then it seems understandable that people should move towards trying to use that particular language as opposed to a verbal one as I suppose musicians do. If they want to have a conversation about music, I'm sure they would really rather play some notes than use the words. I think it seems perfectly understandable that people want to communicate on some level in art and they are going to try to use that art form to get close to that and try to avoid using natural language.

SWG: With reference to that last point, would you prefer to look through the student’s sketchbook and play down talking about the work or would you rather have the student there discussing his or her objectives without the work.

CB: This is a real nitty-gritty question because it focuses upon the fundamental problems of teaching in an Art School. The first thing that upsets most students when they start is the words you use because they don’t understand them. Although they quickly pick up on them they are extremely reluctant to talk about their work and don’t understand, in many instances, how they can talk about it. Unfortunately it is the only means of communicating that we have - it is certainly the quickest and most expedient in most cases. It is only when students, have had enough experience, let’s say in the case of this department which we are sitting in at the moment, the sculpture department, only after a certain period of time has elapsed usually 18 months, two years, sometimes even longer, when the students have had enough time to have produced enough work that they have enough experience of an entire working process to evolve their own understanding of their rhythm in terms of drawing, making, and so on. Not so much in terms of talking even though a lot of that goes on. It is only a means to helping this other thing along. it is not until that time when one can, often oddly enough by having to use words, point to something, making gestures or just using words to indicate that it is this bit of the sculpture you are talking about or that bit of the drawing or this relationship. Then you find that you can really have discussions with students which are to do with the visual or intellectual qualities of the work and it is not really to do with words. The only reason we use words is because we have to have a conversation but the students very, very quickly understand that you are understanding the work in a visual sense. They very quickly understand that their work is visually communicating to you.

SWG: Do you believe it is theoretically possible to have a meaningful discussion...
with students about sculpture without any reference to sculpture or photographs of sculpture?

CB: Only if they knew the sculpture you were talking about but you could, yes one could, have discussions about sculpture with students without referring to specific sculpture or slides or books, or photographs, whatever. Of course it is a limited exercise. A very classic one which has become a classic in recent years I suppose, one which is often used in art schools is to talk about our own bodies, you know, we two are sitting here on two chairs and we can talk about the nature of how it feels and what our experience of that in the past has been and so on and then we are talking about potential sculptural aims and what we can tackle and we can refer to that. It is much more real than talking about photographs and books.

SWG: How do you encourage the development of drawing for students? What sort of experiences do you put their way?

CB: It is very difficult to put in a nutshell because we try many things and often change these things from year to year. I'll give you an example of a fairly normal kind of exercise that we give to students. Most students experience art not through making but through drawing. They have to conceptionalise, they are forced to, they can't avoid it. They have very little experience of thinking truly in a three-dimensional way. So I have on a number of occasions given an exercise, usually a modelling/constructive one. It is an exercise in understanding three dimensions and I choose things that seem very mundane and for which students have preconceived ideas of how boring they are. I would define certain characteristics say within a figure or within a still-life that I want certain individuals to become involved with and I ask them to focus on certain kinds of relationships. They then have a certain amount of time to model this and with any luck they find the modelling they are doing is different from what they expected. It is not a copying exercise, it is an interpreting exercise and they begin to deal with certain relationships which have evolved from the original problems they were given or ones they have now begun to recognise as of interest to themselves. I don't allow the students to draw, and a lot of them have a lot of trouble with that, they just can't, you know, they have withdrawal symptoms. However the next part of the exercise involves drawing the arrangement from the same point of view as the modelling exercise earlier. The drawing produced now is an entirely different kind of drawing from the one that they, or a controlled group of students would have done. It's entirely different because it is informed by the experience of making.

Sometimes I have let people draw for the first day, and you get the usual sort of drawings with no direction, they scribble away hoping that something is going to
happen. I then say O.K., you can't draw any more, let's carry on as though the exercise had begun without a drawing and then we return to drawing later. It is interesting to get the students to discuss the difference between this kind of drawing and the drawing they might have anticipated you would have done without the exercise. How the drawing demonstrates to you as the person who has done it; how you think, let's say, of that three-dimensional object or that group of three-dimensional objects; how you anticipate you would tackle it as a problem.

Drawing is only a skill, which artists of all kinds are normally trying to develop as a tool. To draw a parallel with the English language, make a comparison between, let's say, developing an experience within a certain kind of material and the effect on how one would work with maybe another set of materials which would finally be presented in. I am not saying this very well, it would be very much better if I said what was really in my mind rather than trying to draw comparisons. Not so many years ago I decided I wanted to do a series of small bronzes and in order to do this I had to learn something about bronze casting. I have always been a modeller of some kind - a constructivist. I knew about modelling in casting as I have had a very broad experience of it in a number of materials. I began to model, then I did a cast in bronze.

The experience of going through the whole process of casting in bronze and having the finished object in bronze completely changed the way that I modelled for the next bronze, therefore the information I had gathered about the process had an effect on how I worked towards an end product in that process. So that's forgetting drawing, I mean drawing in some cases has a very important part to play.

SWG: You say that drawing can have an effect on the finished item, have you experienced the use of deliberate ambiguity through drawing?

CB: No, in a sense I am reinforcing. An understanding of the material that you are finally going to produce your product in, will affect every part of the process you go through, it can include the drawing but it doesn't necessarily have to include the drawing. For example I have a piece here. In the development of this I did not draw it, I just made it. At no stage was that a drawing. What I'm saying is it is the material, the practice of using and understanding and experience of using the material, which is really the most important part. Drawing is merely the tool.

SWG: I accept that. Has drawing ever played a major formative role in the development of your work? Have there been occasions when drawing has totally changed the way you saw something, maybe some happy chance when a drawing has evoked something that you knew was just what you wanted?
CB: I can answer yes to that, but I don't know whether it might not have happened without the drawing anyway. That sounds very complicated. For me, the process of creation is very much a collection of events which are to do with making, materials, drawing and so on. But on another level it is concerned with trying to achieve an intensity of concentration and drawing I think is one of the parts of the process which can allow you to do that. However I don't think it is absolutely necessary to have drawing in order to do it, although I recognise that it has happened on a large number of occasions that in trying to solve a problem that has to do with three dimensions I use drawing and use it very successfully. The only reason I am doubting it is that in my experience as someone who has been involved in creative processes, I often go back to using drawing because I don't normally have enough time to make a sculpture. If I know that I have two months to do something rather than six then the pressure's on and I use drawing because it's a quicker way of turning over something. Ideally I would go straight into making a sculpture. Nevertheless I acknowledge that in Art Schools today we perpetually draw. Some of the reasons we have already discussed but it is also concerned with the idea of the Renaissance man - to be flexible.
Interview 6

MIKE FULLER

Architect, Pick, Everard, Keay & Gimson, Leicester.

RICK WELLS-COLE

Architectural Assistant, Pick, Everard, Keay & Gimson, Leicester.

Interviewed: 17.2.1988

SWG: Can we first talk about what functions drawing performs for you.

MF: What a question. I always draw and it is close to my heart as well. We get an awful lot of graduate architects who can't draw, which is interesting because in architecture most of it is straight lines, they should be able to use a straight edge. One is trained to draw in orthographic projection, isometric or in perspective and a lot of people who can't draw learn to formalise their ideas in that way. I'm a bit different in that I can't remember a time when I haven't drawn. I like painting and drawing, it is the sort of thing I do as a pastime. As for architecture I am sure that I use it 90% of the time to communicate ideas. It is something I have spent a long time thinking about, do I have an idea in my mind which I then put on paper or do I explore an idea in lines on paper. I suspect the truth lies somewhere in between. You have a visual idea which is ill-defined or abstract and you try and produce a less abstract demonstration of what you are thinking about by putting it on paper. I have spent a lot of time actually thinking about just the sort of research you are doing. How does an architect think up a building, think of the design. I don't honestly know how I do it.

RWC: When I was training I certainly found that people who could draw tended to fare much better than people who couldn't and certainly the people who were the best artists within the year turned out to be the best architects in terms of the way they create buildings, they were the most adventurous and often the most confident.

SWG: Does technical skill in drawing have a relationship with creative ability

MF: I think it has something to do with the way you view the world. When you do draw you look at things much more thoroughly in a much more concentrated way than if you don't draw. I know that. I spent four years going to the Adult College of Education here in Leicester doing life classes and portraiture. Initially this was to improve my freehand technique of drawing and I found it incredibly difficult at first. I could draw architectural, geometrical things perfectly happily but when it came to making a human form or a face look realistic the degree of precision and observation that was necessary was far more intense than I had ever really conceived. If I was to
draw you I would spend hours just looking at every single tiny little shade and shadow. Architects always look at buildings, when they are walking down a street they are looking at the street scene, not just at eye level.

RWC: Nowadays I am always looking.

MF: When you are going around you look at things. I think we see things probably in a more detailed and intensive way than a person who has not been trained or is not interested in three-dimensional design.

RWC: I think that is the key to it. It brings in the third dimension. You can be an architect and do a design in two dimensions on a drawing board but it is very difficult to design in three dimensions unless you are competent at drawing.

MF: Absolutely. The other problem is such drawing is using communication, the communication of ideas. The vast majority of people we show our ideas to in two-dimensional form, i.e. a drawing, don’t understand what they are looking at. We tend to tie in graphic interpretation with a completely idiosyncratic language. Most people would not refer to a building facade as an elevation and yet we bandy these words around, plans, perception, elevation, projection, axonometric, orthographic. It’s a complete language which the majority of people just haven’t any idea about and I think you have to be very careful when you are talking as to what sort of language you use as well as what sort of drawing you show. But the pencil, that’s my principal means of communication.

As Rick said, the people who can draw turn out to be the best designers. They have this sort of inbuilt ability, they have been drawing ever since they can remember. I don’t know whether those people who can’t draw have the same brilliant ideas as somebody who can. It’s a bit like somebody who can’t write. There’s been a book published recently by a spastic who can’t communicate in any way at all but he’s managed by using his head and a prodder to write a book. It shows that inside there is a guy with tremendous creative talent and understanding of the world, a very fine understanding but until he got his typewriter and this thing on his head he couldn’t tell anybody about it. I think that’s possibly similar to the facility offered by a pencil some people. How else can you communicate a three-dimensional idea other than by drawing it, or building it as a model which takes so long and is so expensive if you are in a commercial situation.

SWG: What about the role of mathematical notation?

MF: Yes, using mathematical co-ordinates. In fact we are becoming involved in
that area with the use of computers which only think or operate in terms of co-
ordinates. We are having to get very much more aware of referencing lines or planes in
space to bases or starting points. That is something which is growing very rapidly.

RWC: I'm more mathematical in a way. When using a computer you have to tie
everything down to a fixed point and you give co-ordinates for every line you draw. It
takes away the fluidity of a pencil. I'm not talking about art, I'm concentrating on
architecture which is a very precise sort of art. It's very difficult to design buildings
with abstract shapes, different textures and colours and so on. I reckon that a good
painting is about 70% accident and you can have a lovely happy accident and ruin it the
next second by putting a wrong brush-stroke on, it changes the expression of a guy
from a smile to something else.

SWG: Is creative drawing very limited today?

MF: I think it depends very much on what sort of person you are, which in the
long run determines what sort of organisation you work for and what sort of work you
may be engaged on. 99% of the profession in architecture are engaged upon making a
living by designing fairly mediocre buildings for money. 1% are engaged in producing
fine architecture. We would all like to think we are engaged in producing fine
architecture and we do try to get some way towards it but when you get to my age and
you've been in the thing as long as I have, about 30 years, you become more realistic.
There is plenty of room for originality and for a bit of fun. I think we have over the
past few years when I have been working for Sainsbury's. You've seen some of the
stuff we've done. The group I am in charge of design supermarkets. You might think
there is not much scope in supermarkets. I often think there isn't myself. The client
knows precisely what he wants but we have had a lot of fun. Most of the fun is going
to end up in the bin but it has been fun. We start each new project trying to sweep
aside all the preconceptions, unless it is a rush-job where we have got to produce
something within a very short deadline. But if you've got a little bit of time then it is
nice to just play with some ideas.

SWG: How do you play with ideas?

MF: On paper. I wish I could show you. The first lot of Norwich drawings I did.
There were seven A3 sheets which I just spent sort of doodling really, just playing with
ideas, thinking about supermarkets, people pushing trolleys and this sort of thing. I
came up with some building forms and ideas which I took up to Sainsbury's and
strangely enough, this is another thing which I have definitely discovered and can say
with absolute positive conviction; ever since I was a student, you are handed a problem
that says you've got to design a supermarket or a hotel or a shop or something and it
gives you the requirements in terms of how big it is, the floor area, maybe a site. I've talked to a lot of people about this, you have an idea on the back of an envelope or something, as you read what is required, shapes and ideas form in my mind and I very often put those down, very crude forms, just a few lines. I have of ten then swept them aside because I know I haven't absorbed all the problem. You then go away, do your research. look in the latest glossy magazines and all this sort of thing and slowly agonise, agonise, agonise over the thing, throwing paper away, sketching away, nothing comes together, nothing works, no ideas, until suddenly you wake up in the middle of the night or you draw a line on a piece of paper - we'll put a wall along there and we'll run the entrance here - and the whole thing begins to sort of assemble itself very, very, rapidly. The grid works out, the structure begins to work, the windows, you know it forms itself into a three-dimensional design very rapidly. It's very exciting.

The strange thing is, when you go back and look at that initial idea which you had before you had really absorbed the problem, the similarity is quite extraordinary. Now I would love to know how the mind works. Is that rooted in the subconscious as a preconception which then, as you build up all the information you need, all the parameters that are needed - and there are a lot of them for a building - you subconsciously force them into that preconceived idea or is it that it was the right idea, somehow the brain has managed to absorb the main parameters of the design and instantly trumped up an appropriate solution. I don't know. It would be a very interesting line to follow.

SWG: Is it important to draw from the very beginning of a project?

MF: Is drawing any different actually from writing, or calculation on a blackboard. When you watch physicists working together they come up with the most incredible, abstract designs, formal diagrams of how atoms and molecules join together. They are thinking in original terms all of the time and that is the form they choose to communicate in and to play about with, to manipulate. rubbing bits out, putting bits in.

SWG: Is drawing taught formally in architecture these days?

MF: It used to be, when I was a student, but that was in the 1950's. They didn't allocate a lot of time to it. We had a life class twice a week which would have been probably about four hours altogether. We had to do painstaking drawing exercises in terms of geometry and understanding the casting of shadows. We had things we had to do called 'testimonies of study', we had to do one in various subjects and they took weeks to prepare. Draw an Ionic column and then cast all the shadows on it geometrically. You can do it but it takes weeks. It taught you a lot though. In a way
it wasn't bad, that sort of classical way of going about things. It taught you to look at things. It taught you to use your eyes and understand. I remember I chose a sphere, a pyramid, a cone, a cylinder and a cube, those five objects. Generally they were arranged and then you had the light coming from 45 degrees from the left and 45 degrees on plan and you had to draw the elevation, the plan and a side elevation, the three projections of that, with all the shadows cast on the surfaces and cast one upon the other so you would get the shadow of a pyramid falling on a cone which presented quite interesting problems. I finally ended up building a model of it and taking it to the photography department and setting it up with floodlight to see what happened with the shadows in order to draw it. Again it was good exercise you see, tremendous exercise in seeing how this thing worked in space.

RWC: All they teach now are ways of improving your presentation, plans and elevations with very little fundamental drawing. When I went to Nottingham we were told that Art didn't count. You had to have two 'A' levels but Art didn't count at all which was extraordinary. I keep on having to remind everybody that architecture is 1% designing and 99% nitty-gritty chores like answering the telephone, writing letters, getting the thing organised, getting it built. A supermarket, for example, the sort that we are building - roughly seven million pounds worth of building. It's built in a year from start-on-site to completion and if we are lucky, if we are not knocked about too much, it takes about a year prior to that from the start date to get to the point where it goes on site. Design-time is a very small fraction of that 24 months. A very small fraction.

SWG: What should architectural design education focus upon, encouraging a creative capability or developing a technical competence?

MF: I would have a two-stream system. There is a choice of doing a B.Sc or a B.A in architecture in some polytechnics so you have the science orientated guys going off to sites of buildings etc., the arts orientated ones going off into design of buildings but it's a blurred and unreal distinction. I'd like to see two streams, the business architect, the one who drives the desk and the architecture architect, who drives the drawing board and does the concept. That is probably too loose a division.

SWG: Do you see architecture as a blend of arts and science?

MF: Yes, it's a blend of everything. It's not just science, it's social science, it's history, it's art, it's a blend of everything. This is why it's so misunderstood. Each individual out there has his own idea of what architecture is. If he's a builder then it's bricks and mortar, if he's a social worker then it's a place for living in, it's an environment containing a unit or units of individuals. If he's a scientist it's an
environment which has temperatures and degrees of lighting and so on and if he's an engineer it has stresses and strains which are being transmitted down to the earth. They all look at it I'm sure in their own understanding of what a building is. We try and look at it in all those aspects, obviously we do employ specialists to work out the engineering, the environmental engineering and so on, but we are, and still are, the leader of the team and point them and guide them in the direction we think it ought to go. It is always teamwork.

SWG: Let us consider computers then. What are and what will computers do for the architecture profession?

RWC: I'd like to think you can do anything with them. The problem is, I think it's very efficient at doing the more mundane tasks. I think a lot of it is people's attitude because it's a new medium and people don't see it as creative. They see it as a sort of workhorse. I mean architects have been trained now for thirty or forty years working on drawing boards with, pencils and they can't just change over to working with computers overnight. It's going to be a longer process.

SWG: Do you know of any architectural groups who are really exploiting the potential of computers?

RWC: I know of people like Arup. They've got about 25 workstations now. They produce some of the slickest, the most thought-out buildings you could imagine.

MF: And they also produce an awful lot of very mundane ones which never get into the glossies, you never see them. That's the bread and butter. They produce a couple of buildings a year which bring the rewards.

RWC: But I think ultimately the computer should improve architecture.

MF: I'm sure they will. We've had CAD now for just about a year. We are still learning, I think we are about half-way through getting to know what we can do with the fairly limited system that we've got. It's a two dimensional system, it doesn't create a three-dimensional model of the building. It's a deliberate choice, mainly because of expense. It's not as expensive as it used to be but it's still a considerable outlay of money and it's no good spending all that money on a tool if you can't make it pay for itself very quickly. It's my idea and I've been responsible for getting CAD into the office. If we went to three-D, before you can get anything out of it you've got to put the third dimension in and that takes almost as long again as putting the first two dimensions in. We want results so, as Rick says, it tends to get used as tool for producing drawings quickly, a drafting tool. I have never seen it like that, I still believe
that it can be used as a tool for designing. However, if you are designing a building, you've still got to draw it out in fairly considerable detail to see what it looks like. A rough sketch is not enough, you've got to go into a lot of detail to see what it looks like. Traditionally if you don't like what you see, you then put a piece of tracing paper on that drawing and draw it all over again even if you are only going to alter a little bit of it. That is a very very tedious business. You may have to make a dozen innovations each of which takes a day. That is twelve days work just to get to something you like. With the computer you can do that so much more quickly, you can modify little bits and still get the full effect instantly. The problem is that at the moment we haven't many designers. Rick is the closest we've got and Rick has not gone right through the architectural school. What I am hoping for is that shortly we will get a graduate architect who we can train to use the computer and he will be the first of the new generation of designers using the computer as a design tool as well as a just a drafting tool. What will happen I don't know.

SWG: How important will drawing, in the traditional sense, become as computers increase in sophistication and number?

MF: I think architects will get on without any skill with a pencil at all. I am thinking here of the technical aspect of drawing on the computer. They don't have to know how to hold a pencil, what sort of pencil leads to use etc., providing they understand the various projections we use for reproducing three-dimensional objects on two-dimensions. But they won't be good designers. I don't know what makes a good designer. I think drawing may have something to do with it. It's a part of the equation but I don't think it's the whole. It may be a lack of inhibition. You've got to be pretty uninhibited to be a designer - to forget whether you can build it or not or whether someone's going to like it or not, just get on and do it. The ability to think very, very fast, I think this is another aspect of it. Painstaking, plodding sort of people don't make good designers, it's the guy who says "come on, I know what you want, you want to do it like this" and there it is. It sort of grows, it's there. The guy who starts at the top left-hand corner of a sheet of paper produces competent design but by no means original or brilliant. Would you agree with that Rick?

RWC: Definitely.

MF: And the guy who can draw seems to be the guy who can think quickly." Maybe he's got a whole lot of bits and pieces in here that he has gleaned over the years which he assembles rather like a computer. You know bits of drawings and you can pull them all out and assemble them into a design.

RWC: If you've got an overall image in your head or some idea and you need to
communicate that, and you can put it on paper in a minute you've got such an advantage over a guy who takes an hour.

MF: The other thing is your thoughts and your ideas are coming so quickly that to pluck one out as it goes by and fix it is quite difficult. I find that anyway. As soon as you have put one thing down there is another thousand thoughts have gone by, another thousand frames of the film if you like have gone by.

SWG: Do you think that computers can ever become an extension to the human mind and body in the way that a pencil can in a skilled hand. Do you think it will ever interact in the same very sensitive, subtle way?

RWC: Ultimately, yes.

MF: I have no doubt whatsoever. We are not that far away. Rick came here, not having really touched a computer and within a fortnight he had sufficient facility on CAD to produce drawings which we were using. How long have you been here Rick, nine months, I'm astounded at the speed at which you can actually draw on a computer now. You can draw nearly as quickly as you can think in some ways.

RWC: I can draw quicker on a computer.

SWG: What developments do you think will take place in the next ten years in architecture and CAD?

RWC: I think we will get a system where you can plan some elevations which will automatically be converted into three dimensional images.

MF: The other thing I am convinced will come is artificial intelligence. That opens up a totally new world where you can interact with a thinking machine, frankly I don't think they are too far off.

RWC: At the moment we are simply producing visuals for clients who want to know what it is going to look like when it's built. If you can achieve that at an earlier stage, so much the better.

MF: I would like to see a full-colour, walk-through facility created using computer graphics, but I don't see that as the design. That is presenting your ideas which you have already designed and conceived, showing them and communicating them to somebody else in as full a way as possible. Holography could produce the most incredible leap in terms of creating true three dimensional images but in space. It is also
quite terrifying because in the twelve months that we have been working with CAD the whole market place has changed. The computers we have just ordered to replace the ones we had twelve months ago are different. I can see that in six months time they will be out of date.

SWG: Do you not miss the human qualities of drawing in the work of architects like Voysey?

MF: There is no technical reason why you shouldn't have a computer that reproduces a water colour painting using exactly the brush strokes that Voysey used. Theoretically you could reproduce the physical way in which spots of colour were suspended in a liquid medium and how it dried, take into account the texture and surface of the paper, the absorbency and so on and there you've got a water colour. Television has been completely revolutionised over the last three or four years with computer graphics, the Nine-O-Clock news logo, that sort of thing. It is superbly conceived and beautifully designed. More and more of this sort of manipulation by computers is opening up the field. It's going to have it's influence on the design and concept of buildings, it must do.

But originality is everything. As an individual I want to put my original stamp on what I am doing and I wouldn't accept some machine-made amalgam unless I liked the look of it. Creativity is the way you perceive the world, largely it is through the visual media. If a person is going to be creative, I think they find a way of being creative. I don't think there is a creative person who has not found some way of letting out their creativity. You may have an individual who has the most incredible ability to enable the brain to send messages to the fingers and remember things, who is potentially the most fantastic concert pianist but if you never show them a piano, if they live in the Andes or somewhere where there is no piano, they will never realise that potential. Maybe they will realise it in some other way - such as playing the panpipes or making bows and arrows!
Interview 7

PAMELA HOWARD

Theatre designer & Head of Theatre Design, Central School of Art and Design, London.

Interviewed: 8.12.1987

SWG: Could you tell me something about the function of drawing for a theatre designer and what are your objectives in teaching students to draw?

PH: For a theatre designer, we believe here that drawing is the most important thing. Although you want me to talk about it as a conceptual thing we are really sure here that we are training visual artists for the theatre, it is not a technical subject, it is not really a conceptual subject, it is a subject more related to the fine arts then to anything else. When we are selecting students at interview we are looking primarily for an ability to visualise and express themselves through drawing. I am a practising theatre designer myself, I work with the National and others and I just know that the best collaborations I have with directors often come from the fact that I have done very good drawings. Even though the ideas may not be thoroughly developed a sense of the quality of the production and the quality of my work is conveyed through the kind of drawing that I do. It is very important, it is absolutely ace important.

SWG: How do you encourage creativity and what medium or techniques do you use?

PH: I have actually just been to Poland and given a paper on this very subject. We encourage people not to try and think out the solutions before they draw it but to start with a blank piece of paper, start making lines, putting colour on a piece of paper, making marks on a piece of paper if you like, and through that discovering something about the feedback process of drawing. My experience is that whenever I do a play, I never quite know how I am going to do it. I mean I don't know what the play is going to be and I also don't know if I am going to draw it in ink, or in paint and different plays awake in me a different drawing response. I try with a pen and ink, I try with a felt pen and bleach and something somehow makes a response to me. Now I don't know what that is, that's really instinctive and creative. A lot of my work with the students is to try and rid them of preconceived thought and not to be afraid of making very instinctive responses to a piece of text or music. I do think drawing is very much an external expression of an internal response and they haven't to be afraid. Nowadays it is considered that you have got to have a developed concept and it has got to be clearly definable before you start but I think you have got to risk something.
SWG: What about the role of modelling in theatre design?

PH: I think that theatre design is a bit like head, hand and foot activity. You could say that when you work in the dimension you are working with your hands and you are working into space. When you are working with drawing you are working through your senses, and through your head, and when you are actually going into the theatre you are doing all that but with your feet in the actual space. Theatre design is the linking together of the actual space, the scale space that you work in, plus the kind of inner emotional space. It is a linking, if you like, of the two dimensional and the three dimensional activities in the actual act which is also to do with the shared experience of making theatre with actors and directors.

SWG: Have you ever known a theatre designer who couldn't draw?

PH: Of course, it happens. For example, Sophie Fedoravich, who was one of the great designers, couldn't draw at all but she did attempt to put her thoughts down on paper and somehow there is a kind of indefinable quality in her work. Of course one of the things is that there are as many ways of doing theatre design as there are theatre designers, it all depends on the director you are working with, the company you are in and of course the time you are doing this. If you are part of a group activity sometimes your vision can be translated in a number of ways. Now, when you run a course it is shaped by the talent of the people who happen to be teaching it and this course happens to be run in this way because I happen to be running it but with someone else it would be completely different. I am not saying that drawing is the only way to design, I am just saying that is my way. I believe absolutely that this is, you know, the way in.

SWG: You are a very experienced designer, how have your drawings changed over the years? Have you developed a kind of shorthand of drawing that is different from what it was some years ago?

PH: I think my drawing has changed. I wish I had a shorthand, in fact all I seem to have is a very, very, long hand. It seems to be working quite the other way with me, I am obsessed with drawing really. How has it changed? - I think I have developed an ability - I shall have to put it like this. I work a lot from text and I work a lot with actors. People have described my work as 'painting pictures with people' and I know that I have particular ability to take a group of people on the stage and to place them in a space and to make an interesting picture without scenery. at all. I am not very interested in scenery. My own work has changed, my drawing work has changed as my interest has moved away from the traditional theatre designer and I am much more into directing or being like a production designer. I am very much involved with the whole concept of the piece now, in fact at the moment I am writing a play, directing it.
and designing it. My drawing has changed as my demands on myself have got bigger really and a lot of my drawings now are not as abstract as they were but they are much more spatial because I am very interested in groups of people. They are like my paint brushes on the actual stage, they are the same as my paint brushes when I am doing a picture. I am drawing groups of people mostly, I am absolutely fascinated by people and I draw people a lot. I might walk down the street and I see a funny fat man who I perceive as German; so I think 'why is he German'? I draw him to build up a big visual vocabulary. Part of the drawing that we are teaching to students is also to use it as a kind of notation that is useful for you. I hate drawings that are clumsy and don't give you feedback because they are a waste of effort and they are not useful. I am quite workmanlike about the drawings. I am not interested in if they are good drawings or bad drawings and that sort of identification, I am just interested in can you draw a drawing which is useful to you.

SWG: The reason I ask is that having talked to many different designers it seems that the way that they actually go about their craft now is different to the way students are taught. I wonder whether you have any views on what students ought to be taught to do as part of designing?

PH: I think as a teacher I am really concerned with going round on a one-to-one basis with my students, looking through their sketchbooks and I might say, "I understand that drawing, that is a wonderful drawing, that is a lovely little sketch" and try to find for them the way that they can develop their drawing, the way they can express themselves and for every single person in that studio it will be different. If there is one thing I might talk consistently to them about it would be the quality of a line and many of them find that very difficult to understand. I talk to them, for example, about the different activity between writing and drawing. You could say that writing is a wrist activity and drawing is an arm activity and if you are going to have the freedom of drawing you need to first of all be standing or sitting in the right relationship to your work. It is no use trying to balance a piece of grotty old paper on the top of your sandwiches and your rucksack and an old tin of pencils and then wondering why you can't draw. Frequently students will come to me and say "I tried what you said and it doesn't work" and then I have to talk to them about what they really mean by it and who the it is that doesn't work. Very often there are simple kinds of physical things that you can do like standing at the right height or making sure your drawing board is at a good angle to your eye. There is a big physical relationship to your work. I am struck by the fact that they don't teach those things at a basic level. What I say to the students is this, if you are a musician, or if you are a dancer, you know that you go to class every day. You know if you are a musician that every single day you have to practice scales. What makes you so arrogant as to believe if you are an artist that you haven't got to do a drawing every day of your life. Why do we believe that drawing is
simply a matter of reading about it or being told about it? Why should people be unwilling to develop skill by practice? It is an incredible arrogance and I think if I could teach anybody anything at a primary or secondary school level it would be to understand that it is really part of a consistent programme of building things up, slowly, slowly, slowly.

SWG: What are your feelings regarding the contribution of drawing to the school curriculum, say, the age group 9 to 16 or 17?

PH: I can only say that I think any education in that field is good if the people who are teaching it are enthused about the subject they are teaching. I am nervous about the kind of formulas that people feel they can put forward about these things, I mean just for example we don't count at all here the A level and O level work. As far as I am concerned it is a dead loss, it makes no difference to our applicants here whether they have done A level or not, it is just crap, frankly. It may have given them a small insight into what they were doing but I am nervous about the actual standard - the standard of visual perception that people have. The whole question about drawing is how do you look at the drawing and what kind of self-critical ability do you develop and what kind of critical awareness do you have.

In a sense the drawing is not so important, it is how you look at it that is important. It appears that in schools the simple act of doing it is in itself the reward. This is very true with computer graphics for example whereby the mastering of the cursor and the menu and all this sort of thing is in itself quite an achievement. I have done quite a lot of work on the Quantel Paintbox and you are so delighted to get anything on the screen at all that what it is is actually of secondary importance. I think this is actually quite dangerous and I worry about that a lot.

SWG: Does that mean that computers don't have a function in theatre design in the future?

PH: Well, I don't think they will make better theatre designers. I think they will help us get rid of a lot of boring work. We have had computers in the theatre for years, we have had computerised lighting boards to the n' th degree and we have got computerised lights, you can stand there and press the button and you can alter the angle of the light at the back of the Opera House. It doesn't make a better lighting designer, it makes life easier so you can perhaps do more jobs but it's a tool, it is no more than that.

SWG: It doesn't help the creative aspect?

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PH: No, I don't think so. We now have a system in the theatre whereby you can overlay plans, you can do three-dimensional projections of different theatres you go to. If you are doing a touring show you can see all the different venues that you are going to go to in the dimension and all of that. Great, but it doesn't make you a better designer.

SWG: You said you would accept students on their portfolio alone.

PH: They do a set test for us also. We choose two plays a year and we give them a little kind of briefing. Last year for example the choice was 'Waiting for Godot' or 'The Knack'. We are not really that interested to see how they design it as such, we are interested to see how people approach a problem that they don't know how to do and what do they do about it. By doing that it gives us some kind of equal sense of comparison because we get an enormous application here and from a very, very wide area and a very wide age range. In fact we go right up into the 30s and 40s in age range that come from quite extraordinary backgrounds and they all seem to end up in the junkyard of theatre. So it is very good to have some kind of unifying thing and then compared with that we then go through their portfolio with them.

SWG: Is it possible to identify what you are looking for, you say you are looking for the strategy they use, is it possible to identify particular elements of that strategy?

PH: Yes, we are looking for people who, on the one hand, when given a problem that they haven't the faintest idea how to solve, will actually practically do something about it. That is to say they will go to a library and look up a book. They won't know which book to look up but they will find a cross reference to it or they will go to a gallery and look up pictures and a picture will suggest another picture. So it's kind of lateral thinking in that way. We are looking for people who are passionate about something so it could be that somebody will do something which is completely daft and I am quoting an actual instance now, somebody who was crazy about knitting and couldn't think how to do the set test and so she knitted it. Now it is ludicrous because of course you can't knit a set for the theatre but it doesn't matter because there was a girl who had a complete passion about something. I don't think you can really do this work unless you are really passionate about it so we are looking for very self-motivated, very committed people who can take a problem and then actually do something about it.

SWG: Is it possible to teach that or is it just a natural God-given gift?

PH: Well, that kind of energy - I don't think you can teach that. You can inspire people, you can lead them, but I think when you are interviewing you are looking for
people who have got that. As a matter of fact I believe absolutely that it is perfectly possible to teach drawing. I teach drawing myself and I have never had the slightest doubts. I've got two kids, well they are 21 and 17 now, and they have been through that whole phase of saying "I can't draw". At the moment my eldest daughter is on Foundation at St. Martin's having said all her life "I can't draw" and is now doing some very good work. I think we are taught that there are certain rights and wrongs and this hinders work. Actually anybody can draw, just as anybody can sing, you may not do it brilliantly but you can by constant practice improve it an enormous amount. I think you can teach critical awareness by conversation, by looking at the students' work, looking at it critically. I think if you asked the students here they would say "she is never very kind to us" because I don't particularly tell people they have done well because I'm not them and I haven't done the picture. I would probably say "look at the way you have placed the colour on the paper there", and "it's very heavy the way you have put that paint on" or "that line, why did you use that pen", or "you could have used something that would have given you a different variation of line". I talk to them in those sort of terms to point out things to them. So I think you can teach people to appreciate the quality of their work but that sort of drive and hunger and spark, you have got to have that in you.

SWG: Do you often find there is a lack of vocabulary in some of the activities that take place in drawing which make it difficult to communicate without actually picking up a pencil and drawing?

PH: I do, but I don't think that is a bad thing. I have always thought that as a teacher you shouldn't be self-conscious about drawing in front of students. I think you should be able to draw with a joy and an abandon to show them that it doesn't matter to you if you don't produce a masterpiece. I think this brings me to a very important point. We are terribly conditioned to thinking that if we do a piece of art work it should always be like the Mona Lisa, that it should be a masterpiece, and this is very inhibiting to people. I think we should be talking about drawing as another form of sensory expression. It's not writing, it is another activity and it should be a natural expression. We are not worried about doing a good drawing or a bad drawing, we are just worried about how can we express that feeling which can only be expressed through drawing. I say to a student "look, if you can write it, don't bother to draw it" but the drawing has to express something that the writing can't, maybe how you stand, what the whole feel of your body is, your character, all those ambiguous things that can't be contained. I think that there is a danger in trying and find language to express that because drawing is a much more ephemeral thing.
Interview 8
PATRICK IRELAND
Freelance illustrator, Maidenhead
Interviewed: 2.2.1988

SWG: Could you begin by describing the function of drawing for you in your work as an illustrator.

PI: The activity of drawing to me is, a means of communication - of conveying ideas to other people. I mean, if I go to an agency for example, and I'm talking about a layout and a certain style of figures, then it is usually done with the use of a drawing, one starts to sketch, make suggestions. I work with publishers a lot, doing layout work for the books I write, again when we are discussing an idea at the early stages I use drawing to illustrate the discussion.

SWG: Does drawing work very actively for you in the creative phases of design work?

PI: Yes; it's a kind of hand-writing really. An idea in the mind begins to come through onto the paper and then it develops and as it develops you see other possibilities. I always sketch when I am working out any layout, it's always a series of very quick sketches which I probably wouldn't show to anyone, it is always only for my own use. I haven't made any real decisions at that stages they are just thoughts and ideas and development in the work that I am doing I do the drawings and the layout and that's how the books evolve. If the art director or the editor doesn't like the layout for some technical reason I would change it but that's usually up to me.

SWG: Are you provided with the complete text to go by?

PI: Yes, well in some books I do the whole thing. I have an editor comes and makes some comments and the art director who might say something and then the technical person who says we can't do that it costs too much, take that cover off, that toning will have to come out, we are not printing it on certain paper”, they all have their own little rules but basically that's how I'd work, it's all on paper, drawing and roughing it all out, it makes you feel more secure.

SWG: Do you think drawing is still a vital part of design education?

PI: Always. I have a class tomorrow for fashion illustration and I have them for
seven-week blocks - this is their second year. As an exercise I may get them all to
draw, say, a figure and then we may represent perhaps tweeds, I would bring tweed
for them to represent. I will supply them with a whole lot of different media like
markers, coloured pencils, inks, wax pastels etc. The drawings are usually
photocopied about ten times so they don't have to keep redrawing it and then on each
one we try the same effect with the tweed but using all the media, so they have the
opportunity of seeing how they relate to that different sort of technique.
Experimentation is very important.

We've got to be careful here because one might be training people to do fashion
illustration and that's one thing or you're training people to be designers, and do
fashion design drawing which is something else and often the two meet. There are
people who do very charming fashion design drawings which can be used for
illustrations and usually those people only draw in a certain stylised way and that's it,
but an illustrator is able to adapt and understand and has the power to produce
illustrations for different purposes. A designer is drawing really to put ideas down on
paper to develop ideas.

SWG: Does graphic ability assist the development of this understanding?

PI: That is a good question. There are students who are excellent at design and
have a wonderful understanding of fabric, colour, silhouette and so on but they are not
particularly good at drawing. They have problems in putting their ideas down. It is
important that they are able to express themselves on paper, even if it is diagrammatic
which is acceptable because even if they can't draw terribly well they can develop a
way in which they may not look wonderful but they'll be clear and they can convey
their idea to the people in the sample room or to someone who is perhaps going to cut
the pattern. Communication is very important to students but then it is also important if
they had to draw up a collection, and they were professional. If their skills were not
very good in drawing, they would get, hopefully, someone who is freelance to draw up
that collection for them, like myself.

SWG: Do you draw as a hobby?

PI: Yes. I've started doing it again but I haven't for a long time, Suddenly I
bought several big sketch books and I'm going out sketching. I like doing barns and
houses, streets, architectural things. I like using pen and ink with wash, inks, water-
colour washes. I like to experiment. I often take them and get them photocopied,
reduced, enlarged, take sections off them and blow them up, retrace them, play around
with them, stick them in a sketchbook and then work on top of them, but that is purely
for my own pleasure, that's not professional. like to move away from my work a bit
from time to time, when I can, purely as a complete relaxation, still drawing but not fashion, which is what I do a lot of and it's quite refreshing. I attend life classes once a week at the week-end.

SWG: Have you noticed any particular difficulties that student have in learning to exploit drawing.

PI: That's why they have asked me to take these students. They have great difficulty in getting them to experiment with different media and drawing figures and so on within their visions. I mean they all do airbrush work very professionally but they are rather dead looking and they can't seem to get them to put figures into their work and also they are very reluctant to use new ideas in the way of different materials, so this is why they seemed lucky with the fashion course and they have asked me if I would do something similar with their students. So that is how it came about, it's something quite new, it took me by surprise because they are not students I normally teach. I suppose there aren't barriers really, things do overlap.

SWG: What sort of exercises do you put them through?

PI: Well I've got this sort of little technique that I use, first I get them to draw figures, live figures. Once they look good I get them photocopied and this gives them confidence to experiment on those drawings without becoming too precious because if the drawing is just a one-off drawing they are afraid they will spoil it and they play around with it very gently. I really want them to experiment and make mistakes and learn by mistakes, or make mistakes and see what comes out of it. So I just photocopy a lot of the sketches, we have the facilities and enlarge them and reduce them, take sections from them and at the end of the day there is a mass of work, spread it all out and then we can begin to criticise and look, see what worked and what didn't and what nearly did and why it didn't and so on and the effects are soon achieved. I do that on my courses for teachers, they are like students. They are very good over a short weekend, you know we start on Friday night and finish on Sunday. They all get very competitive and they want to turn out work. If you have that facility, you know the photo-copier machines are incredible, I don't know how we existed without them.

SWG: When you work with journalists, how do they respond?

PI: They are quite a different again, they are quite a different breed. At the London College I take them from time to time. It's mainly for layout and they prepare a two-page spread on the subject of their choice with photographs, drawings, cut-outs, text etc., and we do a giant spread on a sheet of card and some of them can draw, some of them can't but it's quite important that they are able to put something down on paper.

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when they attend fashion shows for fashion journals, not that they would draw necessarily at the Show but when they come out. They attend Collections and things like that and then they would pass these very quick sketches on to the fashion artists who would be working on the side and they would work together, so that is very much a communication thing between the fashion artist and the journalist.

SWG: In your opinion what's the biggest barrier that the journalists have to communicating via drawing - making marks on paper?

PI: Well, a lot of them are not necessarily that artistic, they are not that skilled in drawing, this is just a part of the course so they are very practical in their approach and one needs to show them certain techniques such as using a figure guide which they can slip under the paper. Often they can draw clothes but it is the drawing of the figure which stops them and when they draw a figure without some assistance of a guide it can look weird, you know, very amateurish. Line values are important using different pens, thick and thin lines and so on.

SWG: Do you find it difficult to articulate what you mean when you do a drawing in front of them? There aren't enough words in our vocabulary.

PI: It's much easier to be able to talk round a drawing, that's what I like to do. If they've done something on paper, one can look at it and think Ah yes, that could be improved by having a thicker line on the outside, or using a thinner line value on the inside, or emphasising a certain area of the drawing, the texture, you know, perhaps putting shadow round the side of it, one knows immediately. Although the drawing may look very weak it has something and just by using these techniques you can immediately lift it off the paper and once you are able to do that with a student they immediately have confidence in you. But without drawing, just to talk about, well it wouldn't really work.

When I take design students, I mean they do have drawing ability, most of them, some more than others, then it's interesting because you know where you are going with them and you know why you are drawing in a certain way because there are certain ways of drawing for specific purposes especially in fashion. There is sketchbook work, research work, doing research for ideas on a theme, then you come out with your sketchbook which is very free, then you begin to develop your ideas and we use what we call design development sheets and these are sheets working on a theme and gradually letting the ideas evolve, so you wouldn't move too quickly away from an idea. Now these sheets could be produced in different ways. You could line figures up, some do, or they can work in a very free diagrammatic way, or they can be very free and spontaneous. They should have colour on these sheets, they should introduce
texture, pattern from the fabric they are working from, or the fabrics they are thinking of, and there should be sheets and sheets and sheets of these. That's how they should work and then from all those sheets usually certain designs are selected to make up a collection and then they are drawn up with more care. The way I teach I tend to get them then to isolate those designs on to single sheets of paper and they are shown as an image so they wouldn't just be a sketch of a garment, it would be a total look and then on that sheet you would have the back view, the fabrics attached and notes are added. They would be the sort of drawings you would show to a client.

SWG: Can you always tell when a student has got that ability. Do their design drawings stand out?

PI: Some of them have got that ability, they improve and we know they will go on and it's just marvellous to have them around. Then there are others, we've had some today, who are very good at design, very bright and intelligent but they have this barrier because they find drawing so difficult. In actual fact they can draw but what they are trying to do is be as good as one or two others in the group, for instance, who are very talented at drawing. Instead of simplifying their work and approaching it at the level they are at, they try to jump and do very spectacular drawings which look dreadful because they don't have that ability. That's what I find very difficult with students who are not very confident in their drawing. They always want to do very complicated poses and very spectacular drawings whereas the people who can draw and are very talented can simplify their work and they are not pretentious or complicated in their work.

On the courses I take the students are drawn from various backgrounds. They may come from Foundation, they may come from fashion courses, they may have done fine art even, so their skills vary tremendously. Then there are students who have the ability to draw but they don't really push themselves enough, you know they just stay at that one spot where they are at, they don't really move on, they don't make the effort to do so. That's hard going. There was another question amongst that lot which you just threw at me which was a very good one.

SWG: Have the students developed a good technical skill or do they have a deeper, perceptual ability regarding qualities of design.

PI: Yes, that I thought was a very good question, because that came up today. We are designing outfits for cyclists, for a firm who want to change their image. They produce traditional outfits and now they want a kind of leisurewear with a cycling feeling, suitable for cycling but not necessarily just for sitting on a bicycle. Something to be out and about in. We had a student today and although she can draw quite well
she wasn't thinking intellectually through the drawings. She was drawing zips and pockets and seams but they weren't necessarily in the right place on the figure. The pockets were out of proportion, the zip was a big industrial zip but looked more like a squiggle. She had quilting on the shoulders which was supposed to be very soft, soft quilting for cycling and they looked like cushions. It all looked very stylised, very cartoon-like - it looked quite amusing but it didn't really read properly. She wasn't thinking through her drawing and I just sat with her for half an hour today and I re-sketched with a piece of layout paper at the top of her drawing that design showing her as I was drawing and actually speaking. I talked her through it. I said this is an industrial zip, therefore, it would be like this, and this is soft quilting so it wouldn't be like this, it would be like this because it's a thin layer of wadding between two pieces of cloth and just try to get her to think through what she was doing. It looked effective. Students often draw things that look effective but they really don't think further than that. This really big quilting on the shoulders looked like a baseball player you know but it wouldn't relate to cycling in the summer.

With fashion you see, what happens, after they have produced all these design development sheets, the next stage would be to make one or two up so they go into the sample room and then they do a working drawing and the working drawing is a diagrammatic drawing like an architect's plan, showing where all the seams are and the place for the pockets and any information that goes with that sketch would go on the sheet and that goes into the sample room. So they have to learn to do those working drawings, which have to be very precise, quite different again, but very important.
Interview 9

ROD KELLY
Silversmith, Norfolk.

SHEILA KELLY
Jeweller, Norfolk.

Interviewed: 26.8.1988

SWG: Would you describe yourself as a silversmith, jeweller, craftsman, or designer-maker?

RK: I think silversmithing falls between two stools. I have always felt myself as being a poor-man's industrial-designer. I have always had this feeling that I have never been as slick - I have never had a set of felt-tip pens and I have never done the same sort of drawing. Ever since I studied at Birmingham I have always felt a poor man's designer mainly because silver has got a tremendous history, very traditional, a craft similar to furniture, where there still is an amazing amount of reproduction work made today. I really like to call myself a silversmith because I am very involved in the craft and in traditional techniques of the craft but I also like to think of myself as a designer.

SWG: How does your particular skill of 'chasing' fit into this?

RK: There are many techniques within silversmithing. Traditionally when you went to the Central School of Art in London, as an apprentice at the age of 15 there would be a line of people and they looked at you and they would say "you're an engraver, you be a polisher, you be a chaser". You had no choice, that was the way they were taught. They then did a seven-year apprenticeship so silversmithing is often divided up into its own little crafts and in the trade you can see that. There are chasers, there are engravers.

SWG: Do you think you could turn your hand to all the other aspects?

RK: Well I'm really a bit of a jack-of-all-trades. There is a complication for those who have been to Art School, like myself, and who are designers as well as silversmiths because in the trade the designer is the man who sits in the office with the drawing board. The silversmiths are the people who get their hands dirty in the workshop. There are incredibly few apprentices now but in the trade the hairs on the necks bristle because I'm not just an engraver, I am also a chaser and a silversmith and lo and behold a designer as well, which really irritates them. But that is what the Art

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Schools produce - when you do a B.A. and then a M.A. that is what you are. But I feel that now I am a craftsman I am very involved in techniques. The technique which I specialise in is chasing which is modelling of the surface of metal into several layers of decoration. I really wonder why I took to chasing because it is fairly graphic - really it is an extension of the drawing which I do, I am almost drawing with the tools. Maybe I took to chasing because of my initial drawing skills.

SWG: What are your favourite two pieces that you have made?

RK: The two large vases that I have just made. They are chased, a sort of carp and willow design which I quite like.

SWG: Are they your own design?

RK: Yes, although I am using a very traditional technique all the designs are looked on as if they are fairly modern. I am steeped in the arts and crafts rather than the trends of the eighties as in the Memphis style or the TV graphics - they will die in a year, they have no staying power, they will never have the staying power of the sort of water colour drawings done by Voysey, the architect. His and Mackintosh's drawings still have got a lot to say but these felt-tip kids really get up my nose. They really don't have any graphic quality. We should throw away these felt tips and go back to pencils and water-colours.

SWG: We will come back to that. Sheila what was your background because I know you are a jeweller but did you do a jewellery degree?

SK: I actually started in textile design at Glasgow College of Art but I didn't like it very much, I felt I would rather learn a craft. I had to earn a living at the end of the day but I think that basically I was more interested in drawing and painting. I have always been much happier in two-dimensions, I think that was one of the struggles I had at the Royal College - coming to terms with three-dimensional form. I mean it is still is, I find that the things I draw are very lively, the touch to make them into three-dimensions is a struggle in itself.

RK: One of our problems is that I can design and have someone make it but the trade in both jewellery and silver has never run along with the Art School system.

SK: You've got to take it right through from the drawing.

RK: You've got to be able to show people exactly how it's done by doing it yourself - raise it, punch it, hammer it, solder it, enamel it and say to them how it is done.
that. The Trade doesn't facilitate our design work at all, I mean all that happens is designs get watered down and elements get recycled.

SWG: We may come back to that towards the end. Let me turn to drawing for the moment. How does drawing work for you?

SK: I use it to organise my thinking. I find that if I am doing some jewellery, I like to draw it out and colour it. I tend to draw very much rather than make lists, I tend to draw things so I can see them, I put them up on the wall, it organises the way I think when I am actually making the work.

RK: Sheila uses more colour than I do, I have no sense of colour. It is through being a silversmith. I think in the Sixties they started putting different coloured acrylics with silver and wood etc., but really silver is silver. It is very difficult to introduce colour. There are some people who are colouring metals but they are not permanent, they are superficial coatings that come off, rub off, or fall off so really I don't try. I like the contrast between different coloured gold and silver but I do not go much further than that.

SK: Rod does very detailed sketches. He is very, very detailed in his drawing before he starts chasing. I mean he has to organise the drawing on paper before he can move on to the next stage.

RK: I don't think I could fill thirty pages of drawing for one item. I find drawing incredibly difficult, the hardest part is designing, when it is designed - when the drawing is finished, the making begins. When that design is finalised you have almost made it, the thing is almost complete bar the making!

SWG: I can see you would have to do a drawing almost as a map for the chasing to follow, but would you also use drawing to define form, the raising of the form itself?

RK: I think that my drawing has to be fairly graphic and two-dimensional, it takes me a long time to do a three-dimensional drawing of a piece that I am thinking of making. At that stage, rather than look at it too much in three-dimensions I often make white card models. I assemble fairly intricate things, making a very complex card model which never gives the ideal shape of the metal but I know in my head. I also have to use pencils that are sharp - I cannot work with pencils that are chewed and blunt.

Sheila's work is very creative. We say the same things about each other but I think Sheila is far more of an artist, a real artist. I don't think my drawings are very original.
but Sheila can use anything very quickly whereas I tend to look at detail an awful lot and my drawings are very detailed. I'm a front elevation man. I can see when I am drawing it - I can see as clear as day in three-dimensions - but I like front elevations. I like my paper squared, pinned to the corners. The worse thing in the world is a drawing board where everything is marked in degrees so usually all the pens and everything get pushed up on the slide and fall off the back of the drawing board but I like to just use a drawing board as a table.

SK: I never use the drawing board at all. Most inspiration comes when doodling on the telephone - just on a scrap piece of paper, the idea is there and I keep drawing the same thing until I feel it is right.

RK: Sheila's sketchbook is a little notebook with bits stuck in and I think I envy that a little bit. I tend to fill a layout pad, I like a layout pad because you can lay one on top of the other and see the drawing underneath. I do use photo-copying a bit. I will photo-copy a drawing and I'll blow it up 12% so it fits in between the diameter I am going to use. I might photo-copy something twenty times and cut them all out. I cut little bits and then reassemble the photo-copies, and then I might even draw on top of the photo-copies and assemble an image. It gives a good image and I think clients want to see a good example of what they are going to get without seeing a rendering. I can do renderings but they might take me three days to draw up. I might be prepared to do this if it were say a competition in which I had been invited to join. But really three days work all put into drawings which might not get anywhere does not make good business sense.

SWG: Drawing to communicate is quite common but what about the role of drawing in creativity?

SK: I can see things in my head at the same time as drawing them, you know I see the shapes. I am trying to think which comes first. I would imagine the drawing comes first.

SWG: You see something in the drawing and that gives you another idea.

SK: I see three-dimensions in my head and you can sort of see the possibility of taking it further.

SWG: So you are using drawing in an active way to interact with that idea generation?

RK: I must admit that sometimes I do a drawing late at night and it turns out the
best. To me I find the pressure of designing and drawing quite intense really, something I would much rather run away from and I think that's why decorative work, where you are not only dealing in form, you are dealing in decoration, is far harder to do than plain surfaced, industrial design work.

SWG: If you were told to do something without any decoration, without any chasing, would you prefer to get straight into the material, without undertaking any drawing?

RK: I couldn't just pick up the material. You might take £300 worth of silver and you cannot afford to just bend it, you have just got to be precise. If I had to design something which didn't have any decoration, which I would never do by choice, I think I would take on a totally different personality. I don't think I could do it without decoration, although I used to. I don't think my personality, the way I work would suit that, I think I would be a sort of clone of someone else, I would have to draw it first though and then maybe a card model.

SK: I think it would probably be very helpful for me to do something that was completely plain, because I think it is quite nice to explore form rather than decoration but I think I would always come back to colour and pattern. I always want to decorate things rather than just leave them plain.

RK: I do think there is a great art to designing things that are undecorative but I think it is much harder to design form and decoration to go together. The attitude of the Trade is still revolves around making an object then 'where shall we put the decoration?'. Sometimes I'll over-complicate the form, thinking that I am being clever or more modern. At night I may look at the drawing and think 'yes', and I'll get up in the morning and sneak back in and look at the drawing board, instantly I'll think 'yes it's right' or I just know it's totally wrong. If it's totally wrong then I start looking at it and doodling. That's why I like to leave the pages on. I find it very difficult to go from one page on to the next clean page. It's always the biggest struggle of all. The page is full and I think 'will I lose that, sort of like losing the gist of a story, before I get on to the other page?' It is always a real relief when you are on a new page and there is some work on it. That's why I like layout because you can see the other work but I find it difficult when I am showing to clients, it's only a small point, but when you are laying paper on, I always have to take sheets of card so they can see the images clearly. I do use Rotring pens occasionally - I find them very technical but it shows the images in greater intensity.

SWG: You are both accomplished craftspeople, how has your drawing changed in say the last ten years?

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SK: I'd certainly say that it's tightened my drawing up a bit. Now I find that every time I pick up a pencil I feel I ought to be designing jewellery. I don't draw as much for sheer enjoyment.

SWG: What has tightened it up, the pressure of work or experience?

SK: I think possibly going through college and being told to concentrate on the making rather than the drawing has had some effect but I think now I am terribly conscious about all this designing for jewellery rather than drawing for drawing's sake which I feel is a great pity. Unless you are free to draw you really cramp the input to the work. You almost have to draw to get new ideas, otherwise you tend to repeat yourself with the same forms and the same shapes.

RK: In my second year at Birmingham I was told that I couldn't draw. Now I would say I am actually quite good at drawing. I think I have just worked at it and worked at it. Some of my drawing was dreadful but somehow it has matured along with the work.

SK: Do you not think that the chasing might have improved you at all?

RK: Possibly. I mean I enjoy drawing but I'm a bit of a cheat. I have a very romantic notion that if I had more time I would go out and draw from life, the idea of moving from London to the country was really to do more drawing outside. I would love to do more life drawing. If you are going to make an attempt to do life drawing, which I think helps the drawing technique, you are always a bit worried that your technique is going to suffer and it may not be as good as you once thought it was. You don't want to risk it. I do quite a lot of designs involving feathers. I once went to a taxidermist in Camden and I rented a stuffed hawk for a week. I sat in comfort with my sharp pencils and my sketchpad and I sat and drew it, that was great, but I wish I could get outside, it is just the pressure of work.

SK: I think people envy aspects of each other's drawing ability. I mean I envy Rod for being very disciplined about his drawing.

SWG: What should a student today, going into the silversmithing, chasing jewellery trade, experience? What should be put their way regarding drawing?

RK: I think drawing is the vocabulary - everything. I don't think you can design without drawing, I really feel that. When engravers were trained they first started by copying lettering. When I first started to do lettering I was taught by a real old hand. It is amazing what you can learn about proportion, about drawing circles, curves, from

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doing lettering. Whoever now would sit in a studio now and do letters? I mean I remember we spent two days doing 'A's and then we asked what we could do and he said let's try B's and that's the way it was. After you did lots of A's you did B's but it's true, you look at the Roman alphabet and it is absolutely superb. It tells you more really about style, curves, linear forms, you could design anything from the Roman alphabet. If students start to use computer graphics too early it can kill an awful lot of creativity. Designers need to paint and draw. I really believe that, but I think now that many Art schools are merging with polytechnics they will lose the thought of an Art School and of drawing and of life drawing. Once you can't express yourself on paper that is when you start to use a ruler and measure between the two and draw straight lines. In silversmithing curves are technically far more difficult than straight edges.

SWG: Have you ever come across silversmithing students who couldn't draw but impressed you with their designing ability?

RK: I can't think of one example where a very good person can't draw. I find using card models very good, because it's quick. Sometimes I use a wooden one. I might turn something on a lathe and spray it white.

SK: I think that students become very easily frustrated with the fact that they can draw and have ideas in their sketchbook but that they can't make them into three-dimensions. They find it very difficult actually to change from the drawing in two-dimensions and to translate it into three-dimensions.

RK: Also their models. If they can't draw they become disillusioned and their models look dreadful. Their models look dreadful because their drawings are dreadful. Sometimes I will ask a student to outline an image that they want to decorate a piece of work with - one beautifully drawn thin line so we can take it from there as an image. They bring it over and they have been using a 6B pencil - fifteen overlapping curved lines and a big black mess. I think for some things it is nice if they can accomplish very smooth linear drawing as well as instant drawing.

SK: I personally think that drawing is very important but for craftspeople I think it is important to have the two going in parallel. I mean you need the drawing input but you also need the technical input and one shouldn't become more important than the other but you have to develop in stages really. I mean it's no good just doing all drawing because you never have the experience of using the materials. I think one has just got to go hand in hand with the other.

RK: If I wish to decorate the surface of a curved vase and I have got the image on paper, occasionally I'll do what they do in the trade and that is use carbon paper, put
the paper on the metal and scribe through to get the carbon image. That is ok. if it is flat, straight and very simple, but if it is curved you find the curves you drew on the paper, when put on a curved surface totally alter. Instead I make the thing in metal, say it is a vase, and I cover it in white emulsion then I start drawing from my drawings, which I spread all around me, drawing on the metal, and I go over and over and over, bits that I don't like I scrub, wipe off and put more white paint so that in the end I feel I can establish what is the design. You can't just take it from paper. I am not saying that my drawing is right for everybody but with what I do, chasing, images, it just seems to go hand in hand.

SK: You think of drawing as a tool, don't you?

RK: It is in its way. I do enjoy drawing, I like looking at drawings, I would like to do more drawing. I would like to draw really out in the street, buildings, be more of an accomplished drawer but you find it is hard enough just trying to be a silversmith. Time seems to be hours and hours seem to be moments.
Interview 10
IMOGEN MARGRIE
Ceramic sculptor, London.
Interviewed: 5.7.1987

SWG: First of all could you describe your background and work within design.

IM: I went to the Central School of Art to study ceramics. In the second year there we did a lot of industrial ceramics - industrial techniques and I did a lot of industrial designs. I went in for a Wedgwood competition designing plates which was incredibly boring. Although I actually won the competition the design had just a couple of lines running round, it was just about as plain as you could get without having a white plate. I became more involved with the Fine Art side, although initially the other work was quite interesting - the actual designing, but it took so long to do. So most of my work has been much more fine art oriented.

SWG: So when you graduated how did you make a living?

IM: I was quite lucky because the Contemporary Art Society bought several of my pieces from the Degree Show and I sold quite a lot more, that was a boost. You never know how it is going to be when you take it out of College, how people are going to react. I was lucky in that several galleries were immediately interested in it so I had some initial work. I then got a workshop space which I fell upon, it's a big factory in Kilburn, and there are about 50 people working there, 10 of which are in ceramics. It is a real haven. I think to work in a little hole at the back of your house would be absolutely devastating. I like having activity around me. It is a co-operative so it is non-profit making. Any money we make goes back into it. There are kitchen designers and people who make one-off furniture. The people in the workshops are generally quite friendly so you can go I and say “I want to make something in wood and don't know how to do it”. I made some birds for my Degree Show which had a hole through them, it was to do with birds being caged and they had metal bars going through them so whenever you saw a bird you actually saw the bars as well. I wanted to make them but I didn't have any equipment and I am not particularly skilled in that area. It was good because the workshop people were very nice.

SWG: To turn to your drawings, how often do you find yourself using drawings and how often do you get straight into the material?

IM: Every piece I do has been drawn previously. I do a lot of drawing. I go to
the Zoo as frequently as I can and I take a lot of photographs. I like the movements of the birds and it is very difficult to draw them I might make just a quick squiggle - I end up with a line which has a feeling but when you come back to the workshop it is really quite difficult to know what you are actually trying to get down. I do a lot of drawings at the Zoo and then I go home and do drawings from the photographs.

SWG: Do you have an idea at the back of your mind as to what it is going to look like at the end or do you just see what the drawing comes out as?

IM: That's it. I do a lot of drawings and select from them. Sometimes it is a feeling from the bird, perhaps it is aggressive or cheeky. One of the pieces I have got now is slightly skewiff, its face and its eyes look like that, it is just a feeling, there isn't anything definite, it's just a feeling I wanted to get over.

SWG: What sort of media do you use for your drawing?

IM: Everything. I have recently got an ink pen for sketching. And I use those crayons, the Caran D'Ache ones that you can water down. It depends how it goes. I use Tippex, anything that happens to be around, anything that seems to be right, just bits and pieces. It depends on the mood again, sometimes you get it first time and you think it has got a nice feel about it and I'll go on to another one and you know immediately you haven't got the right line. It is a different feeling.

SWG: Do you see it as a three dimensional object you are drawing or a two dimensional one?

IM: I am always thinking of it in three-dimensions even though perhaps they are nice drawings as well. They may look like pretty paintings when I am finished but I am thinking of what the other side is going to be like. Construction is the limitation and the majority of drawings I do are made with making in mind. In claywork you can't have birds with extremely fine legs so I tend not to draw the legs!

SWG: Do you limit subjects to those that look like coil pots?

IM: I go to the Museum of Mankind and do a lot of drawing there. Sometimes I get enamoured by something and think 'I must draw that', but I tend to draw things I actually think I am going to make. I also do things such as paint fabric, scarves. I buy clothes and I paint them but I don't actually make them up into anything, I can't sew, if I can glue it, I glue it. In fact I did a skirt for a lady at the V and A (Victoria and Albert museum). It was a very large, open skirt and thinking about how it dropped was difficult. But the things I paint on the scarves are very different from my ceramic
work. They are more... the clothes I wear tend to be more brightly coloured whilst my work is actually quite subtle, if it gets too garish the colour takes over from the form too much.

SWG: Do you ever do more technical work; technical drawings, very accurate measured drawings for example.

IM: Only when I was at College, not since then. I do actually make moulds for the bottom of my work but I don't draw it. I go and watch the people because I can't throw very well. I have to tell them how to shape it. I don't actually do a drawing of it. I am never sure exactly what I want anyway until I see it. There is a girl who works in my workshop space who makes slipcast ware which she then draws. She is trying to sell through places like Harrods and she does the drawings so that they can understand what she is getting at. I know she finds that very difficult to do, to have the freedom of the drawing but still letting them see what is going on. When they see the samples it becomes obvious but it is quite difficult.

SWG: At the moment you are acting as an artist in residence for this primary school. When you are working with children do you get them to use drawings at all?

IM: That is what I have been doing. I think it is very important, especially when, if it is a new material, you are not really quite sure what you are doing. If you have got a drawing there, then you have got something to work from. When it gets slightly out of control you can look at the drawing and say "well this bit is all right but it seems to be going more like a dish", and you have actually got to bring it round. I was thinking of trying to get them to try to draw each other in contours so that there would be lines going round, then take a slab of clay and make the piece. It would be nice to then draw that piece and work from the drawing they had done of the piece.

SWG: So that drawing and making are symbiotic - feeding each other.

IM: So far it has gone very well, their work was really very different. They could say "my drawing has got lines radiating out for the nose and somebody else has got a spiral". There was one child, one little boy I was working with and he got straight in there and he actually made things well - he just sat down and patiently got on with it and it is a really peculiar thing, it is very odd, out of everybody's work his really stands out. There is something slightly odd about it but very nice.

Whilst I have been here the school has structured its curriculum around me with the theme being endangered species and animals, so they have been drawing a lot of endangered animals. There is a slight phobia about 'I can't paint' so I have them doing
collage and today I have had them doing embroidery. They have painted a fabric and then they have embroidered it, and now they are going to stuff it, so gradually they are getting the idea I think.

SWG: Do you have any particular thoughts about this area of drawing and designing?

IM: I can't believe people don't need drawings to make their work come. Some of the people in my workshop don't draw at all and I find that really odd and you can see that their work doesn't progress quite so quickly somehow, it seems to help you formulate ideas, the work may not actually come out like the thing you draw but it is just the sort of process of making, you sit down and think about it.
SALLY MATTHEWS Sculptor, Loughborough.
PAUL O'LEARY Consultant designer, Loughborough.
CLAIRE WEBBER Fine artist, Loughborough.
Interviewed: 24.11.1987

SWG: Drawing can be viewed as a communicative, observational or recording activity, How does it work for any of you as individuals?

CW: All three, communicating to myself, recording and observing. I always feel I have got to learn something - I've got to learn and observe and put it all down. I think what I am looking for is communication to me as well as to other people.

SM: With figurative work, all that you do is observe and find out, a searching process. I think once I start to sculpt, say a cat or something, I can't do that without going to have a look at a cat so I suppose I start off with observing and recording and following the shape and trying to get the shape with a pencil and then when I get it back it is better than a photograph, it says something of how I saw the cat and if I wanted to do a drawing from that draft it would be to sort of communicate with people.

SWG: Do you ever work directly in materials, cut out the drawing phase?

SM: Yes but that's like sketching in your head, you call it sketching because it's the same sort of process. Also when you do a drawing that is really good, you seem to catch what you want, it makes the sculpture so much easier, especially if you are working from an armature like the one outside, You need to draw the wire to get the shape and then you just build up on top.

CW: That is very different to the experience I had at College. There they totally eliminated the drawing, they didn't recognise its importance especially life drawing. It was good to come to Loughborough and learn to draw there, I think it is very important.

SWG: Why do you think they reject drawing?

CW: I think they just have a trendy outlook. With so many people around who could draw the invention of new art perhaps requires a different approach, a different outlook. I think drawing is the basis of developing your creativity because if you can draw you are much more confident about how you draw, then you can start developing
the drawing and that automatically leads on to other things like painting and sculpture. I think as you get better at drawing you jot things down quicker so you are eliminating a lot of things that bothered you before. You get to it quicker but I still find drawing fundamental to my work - to my creativity.

SWG: The drawings of Henry Moore, say, reflect a three dimensional intention. How does drawing assist your design of three dimensional sculpture?

SM: You have got to think three-dimensionally when you draw. You are discussing something in front of you and that is bound to be three dimensional unless you are drawing another drawing.

CW: It really helps me to understand. When I draw a thing I am thinking how it actually looks. Sometimes I do try to break it down into two dimensional line, I imagine I am almost tracing it and that helps me to understand it better.

SM: I can get away from the actual form in a drawing when the line itself becomes aesthetically pleasing - the activity of drawing is pleasing. That is the part of the enjoyment of drawing. I would much rather look at a sculptor's drawings than a sculpture. It is the same with a painting.

CW: If I like a painting it makes me want to look at the drawings but the sad thing is that quite often the drawings and painting are saying two different things. To me my drawings are similar to my paintings, they relate quite closely and I find it strange when it doesn't work that way for other people, nothing coming out in the painting, no transition. I think that people look at the drawings but they don't understand how the drawings affect the product. They just accept them.

POL: I think that most people who haven't studied art in any way whatsoever tend to want to see things they can recognise, for example, if you do a portrait it has to look like that person. The way the marks are put down on paper isn't important to them at all, they don't even think about it, which is a shame because to the artist that is one of the most important things.

SM: I think a good mark should say what it is meant to say and that if a thing is drawn ugly, not drawn in the way it is meant to be, I am sure the general public would be able to see that, a good drawing shouts to everyone that it is good.

CW: It is hard to define a good drawing. Sometimes people try to get away from being totally sympathetic, they may use a big heavy line - it all boils down to what people are wanting to get out of themselves. When I was at College the staff kept
saying my paintings lack what the drawings have got. I find that now when I do a
drawing I try to combine the goodness of the drawing and put it into colour although I
don't copy my drawings, it just gives me an idea, it sparks something off. I try to get
the looseness into my paintings.

SWG: Turning to the product design world, Paul, do you feel a similar desire to see
the early sketches of product designers and why?

POL: If you can’t draw you can’t really be a designer because you can’t move on
from one idea to the next. Earlier on we were talking about two dimensional drawing
and three-dimensional form. When I am designing with Andy I am thinking about a
problem. You look back at the last few sheets and you think we have been designing in
two dimensions all the way through these last few sheets and we make a conscious
effort to start designing in three dimensions. For some things it is more appropriate
than others. Say something mechanical, you can work out how things move in a
certain plane much more easily in two dimensions but then you forget about the overall
form and you can come up with something absolutely ludicrous because you have just
been channelling yourself into a two-dimensional design. Three-dimensional sketching
I think is more productive but it is a lot more difficult because you have to think about
where you are putting a line so that the thing looks right and so you can assess it
afterwards.

I like to see designers sketches but also, I think, it is important to a client. To see all
the work that has gone into coming up with this product is useful to them and they can
also work out why it is the better solution from the drawings. There is no other way of
showing them that, because you can’t get through those ideas as quickly in any other
way except by drawing. Clients do seem to be impressed not only by volume but by
how much is going on in the drawings. Without that they may not have realised how
difficult it is to come up with the end product. It is something they couldn’t have done,
because they know how limited they are in drawing.

SWG: How important is drawing to your creativity as a product designer?

POL: There are certain things you just can’t work out in three dimensions, I think
the only time we rush into 3D modelling is when we haven’t time and it doesn’t matter
about the volume of work we give the client when we have only got to give them the
finished work quickly. But if we are actually going to tackle the problem properly and
go through the long process to get it up to an optimum solution then you have got to
start by drawing and doing a lot of it as well.

SWG: Does one have to be good technically at drawing, I mean, for example by

Appendix I NSEAD project transcripts Matthews / O’Leary / Webber A79
undertaking life-drawing, to be able to use it as a creative tool?

POL: I don't know much about life drawing, I can't really say, I haven't really done all that much of it. You certainly have to build up that skill of drawing and life drawing will obviously help you to do that, but it is helping you in an area which you are not going to use all that often. If you learn how to draw objects in perspective then I think that is a much quicker way of getting to the sort of drawing you are going to need to do.

CW: I think it is a lot easier to be able to draw objects, you don't have to look so hard. It's still understanding but you don't have to go into so much depth - or pain.

SWG: Perhaps Paul's drawings are more concerned with communication, whereas your drawings are much more to do with reflection, an inward looking.

SM: And outwards as well. I always want to draw to help me understand. It's rarely used to express myself although it does happen, it's learning about what you are looking at and being surprised.

SWG: You certainly seem to enjoy the activity of mark-making, of drawing and that's often lacking in some design students.

CW: That's because they are not confident about it, that's all, perhaps they haven't done enough of it. I think it's really sad when I hear people say "Oh! I wish I could draw" because I think they could draw. I didn't used to be able to, it's just a lack of confidence. That is why it is good to be forced to draw when you first start Art college, to get over that barrier, then you start to express what you want.

SM: The thing about fine artists drawings as opposed to those of designers is if you look at fine artists drawings they are not actually precise, they are more of an emotional response, of feeling. The drawing takes over, the marks or the composition whereas Paul, as he says, has to make it look like it is and has to be able to explain to people through his drawing that this is how it is going to work.

POL: In the final stages.

SM: In the final stages and I think with a fine artist they are just saying "this is how I see it".

POL: They are completely different activities. Theirs is emotional and it is trying to find a character and an object and it's trying to express something to themselves. We
are not doing any of that, all we are doing is finding something that will work, something that will look good at the end but the actual drawing doesn't have to look good. We are not studying something, we are trying to produce something, so it is completely opposite.

CW: I think it is in the end but it's not to start with. When you are perhaps starting to draw something you are in a similar position but in the end you want to put it across in a different way to us. After I have become familiar with something then I might become more confident and see it in a different light and I am wanting to see it in a different light, I'm wanting to find new things about it, about the drawing itself.

POL: But regarding the objectives of the person who is going to be a fine artist and the person who is going to be a designer, they are both made to sit down and learn to draw and they are both drawing a chair.

CW: Objectively.

POL: O.K. objectively, but the direction you are going in is a completely different direction to the other and if I start to learn to draw and get character in that drawing and...

CW: Subjectively.

POL: As long as I can draw that chair in perspective and get the form right and get the colour right and the texture etc, that's what I need to do but for a fine artist that's completely different.

CW: I suppose my system of drawing is quite personal, whereas Paul's, if I saw them on a wall I wouldn't say 'Oh that's a really lovely drawing' and want to find out more about them. I'd think of them as a functional drawing.

SM: Sometimes I think that my hand is doing the drawing as well as my mind, the way I move my hands, that's where the personal touch comes in. I think some people just naturally draw scruffy, some draw precisely. It's a natural thing and as fine artists we are allowed to find out what that is.

CW: I think today, going back to Art School, students don't undertake a basic learning process. I believe you have to be able to draw well and paint figuratively fairly well before you can be an abstract painter.

SWG: It seems Paul, that that you are denying that industrially produced products
could have an emotional content, as long as you can draw the basic volumes and shapes you can get away with it, but a lot of our industrial produced products have quite a lot of semantics about them, a product language.

POL: Yes, I thought about that after I had said it. I thought, wouldn't it be nice if people who were drawing to learn how to design could get some enjoyment out of their drawing. They would probably be better designers at the end of it. I also thought about the products and product ranges and how they do have characters - companies such as Braun have a certain style. Now does that style come from the chap who designed them, his enjoyment of designing. Does his character come out in his products? I think perhaps a little bit of it does.

SWG: It seems that a number of our products are designed by people who have a basic command of the grammar or language of drawing, but don't actually get involved in the sensitivity, the sensibilities of drawing language and enjoy it in the way you describe. I wonder, as Paul was saying there, if in design schools we really ought to value a traditional foundation course whereby you learn drawing where enjoyment forms part of the experience. Perhaps this would show in the products that later resulted?

SM: A fine art training is a very good training for other things. Fine artists could often design better things, say textiles, better tables etc., perhaps because they are more open minded about their drawing, more imaginative.

POL: I think you have to limit the products, certainly furniture, then again you have to knock out 75% of the furniture because it has got to be mass-produced. You can do furniture which has a very small market and is very elite. You can do teapots, for instance, but not televisions.

SWG: If somebody came to you Sally and said 'we like the way you work, we are looking for a thousand ceramic pigs or whatever,' They like the way you work, they want to try to capture some of your work in a medium that would suit mass-production. Would it affect the way you work, would it affect your creative process and particularly would it affect the drawing?

SM: It would definitely affect my sculpture. Drawing - no: it probably wouldn't affect my drawing. Maybe I would aim for a simpler line or something but with my sculpture it's usually so one-off anyway.

SWG: So you would compromise form essentially, but that would not affect the drawing. I wonder whether you would employ the designerly type of drawing we
touched upon earlier with a reduction of your personal, investigative drawing?

SM: It would take the pleasure away.

SWG: If I ask you the question, Paul, and say "here's a commission to do a one-off, a piece of sculpture", would that affect your process or your drawing?

POL: We have to compromise ten times a minute when designing something. You come up with an idea and you've got to figure out if it can be done. "No, it can't. It would be much easier if that plate were angled in that way or other", so suddenly you wouldn't have any of those compromises because you don't have to worry about costs or whether the thing can be produced, you can make it out of anything suitable and it doesn't matter how long it takes you, so obviously the whole process is changed because you are not compromising any more. You are still going through that process of developing but without the compromises.

SWG: How would drawing change?

POL: If I were designing a product which was more aesthetic rather than functional I might develop a different type of drawing. Very rarely do we get the chance to put any sort of character into something because it is so functional and very little of it is actual styling.

CW: When you are working for somebody else instead of yourself you fall into a different way of thinking. You start thinking is it all right for them, you automatically work differently.

SM: I think it's a bit like your character, it slightly changes when you meet your parents, it slightly changes when you meet friends. It's the same character, the same drawing, you just bring out a different emphasis. I think the nice thing about drawing is the spontaneity of it. You may have not even intended to do a drawing - you were just feeling around.

CW: Sometimes the best drawings for me are the rough sketches. I remember my Degree show when I put in a very quick sketch. I had other drawings, but this one had much more meaning to it. Sometimes you have an affection towards a drawing.

SWG: Do you ever feel that Paul, an affection towards a drawing?

POL: I feel that Claire has affections towards certain drawings when I think there are better ones around. There is one particular drawing which I am thinking about.
which I really don't like and I think 90% of her drawings are better than this one but she likes it 'four melons and a teapot' and I think it's awful. She's got so many good drawings but she always puts that one up for people to see which I think is a shame.

SM: I think I have affection for some drawings because they catch something which has almost come out without you trying, you know what I mean? As if you've discovered something which you didn't know you could do or you didn't know that about that animal or something.

SWG: Serendipity, happy chance.

SM: Yes, happy chance, it just comes through.

CW: That drawing up there, that's my grandfather. I did about four drawings before that, quite sketchy drawings but I was really looking hard. But it was when I got really pissed off that I got that one. I quite like it because it's quite simple, it looks like him, it sort of captures him. Everything is quite abbreviated, the hands are sort of one line instead of lots and lots of little lines which I was building up before. And the hair, whereas before I tended to scribble it in, it's quite downward strokes and really following the direction of his hair line. It took me almost to get angry to be really direct.

POL: I was just thinking, another fundamental difference between an artists' drawings and a designers' drawings is that an artists' drawings are meant to be kept. No matter what you say you keep all your drawings, they are not actually meant to be displayed or for other people to see but they are all kept. When I have designed something I don't stick it up on the wall or put it up by my desk for reference, it's just gone, that's it and we move on from there.

CW: You quite often say to me "that looks good, sell that one, frame that, that'll be good to sell" and I always think deep down "I don't want to sell them, I don't want to sell".

POL: Sell that useless one then! No, I can quite understand you don't want to sell. I remember when you did that drawing there, I did a drawing of a man at exactly the same time, do you remember?

CW: I've still got it

POL: You've still got it have you. I never even remembered it was around until now
SWG: I presume then you both don't see your drawings as mere preparatory stages towards the finished product, a piece of sculpture or a painting. They are not just tools as Paul would say, to arrive at the solution of the thing you are going to make?

SM: Sometimes they are. Sometimes it's a drawing, sometimes it's the sketch and a sketch need not be for anything else. Sometimes when I do a drawing then it is, but it doesn't have to be. Drawing can be an end in itself for us, you know, a complete end, but it can be a means of moving on.

CW: Perhaps our drawings are different, more messy because you are capable of thinking and moving, catching fleeting movements, whereas Paul's drawings are quite stationary.

POL: I'm normally not drawing anything at all, it's all out of my head. They are fleeting moments in my brain, not fleeting moments that I have seen. I don't think I have drawn for my own pleasure for so long. I don't think I have ever done any designing for myself.

SWG: Is drawing a fun activity above and beyond it potential in designing? I mean, I've seen you and Andy drawing doodles and then turned them into little men complete with hats on. It's fun.

POL: Oh we enjoy having a laugh.

SM: I think what they do is draw little jokes that come into their brain to make the other one laugh.

POL: You can't say that drawing a pair of boobs on a teapot or something is enjoying the mark, you are just having a laugh, aren't you. The only time I can think of enjoying drawing is when it feels good or it looks good, but you never think over it again, you never mull over it. A rendering you expect to be good and if it isn't you are disappointed, but a sketch of something is different. It might be that the design is good or the drawing is good, either way you might get a little bit of enjoyment out of it but you soon forget it and move on. It is not something you think 'Oh that's nice. I'll stick it up on my wall.'

CW: Sometimes when I'm drawing, I'm not aware of getting enjoyment out of it when I am doing it. It is only when it gets to a certain stage, when it starts to look good and I feel confident. Sometimes when I don't feel confident I get quite aggressive. Only afterwards, when I stand back and think, perhaps it's OK, Or looking at sketches the next day and seeing them fresher.
As I said earlier I rarely talk about my work, I just think things in my head, but what I often want in a painting, is something a little bit strange, a little bit different that triggers me off to do that painting. I'd like to be able to do paintings where people would look at them and say “that's by that woman”.

SWG: Perhaps that's something we all need, to be triggered off. We need the emotion of drawing a particular person, object or arrangement. Trigger mechanisms may be personal, and perhaps your graphical jokes are trigger mechanisms that work for you. In one case you quote they didn't provoke further development but made you stop and go back. They made you stop what you were doing, look at it afresh and then you came up with some new ideas.

POL: I never feel guilty about drawing boobs on teapots. We quite often have to stop ourselves. For instance we did 10 sheets for a client the other day and there wasn't one of those ten sheets we could give to them because they were all obscene, every single one of them. Quite often we got almost to the end of the sheet and it's quite clean and then Andy starts! Especially when he is doing it with black biro. Normally one's got a pencil and one's got a black biro and the guy with the pencil is allowed to be obscene but the one with the biro isn't. We have to take it in turns!
Interview 12

NORMAN McNALLY

Product designer, Course Leader Industrial Design, Glasgow School of Art.

Interviewed: 14.8.1987

SWG: Although there are many books that profess to teach drawing they do seem to omit vital concerns.

NMic: Yes, those books are all to do with communicating to others. One of the most central roles of drawing is to communicate to oneself. In some ways the better the quality of the marks you make the greater is that communication. It is like going into a life drawing class and doing a matchstick figure. You may have got the structure but it doesn't tell you much about the actual experience you are having. The better you can communicate your ideas, the better you can visualise your ideas the more real, and the more convincing they become. The engineers at the University, in the ordinary Mechanical Engineering course do a block called Communication but it is only BS 308. It is only communicating to certain people in one very particular way. We are approaching it in a different way. We are showing the necessity for viewing BS 308, If it is BS 308, as a skeletal, economic and elegant way of communicating complex Information.

SWG: What difficulties have you had in teaching them other strategies?

NMic: Well we haven't. I fear we would have had great difficulty in teaching them other strategies if we were starting further up the course, but because we are starting with first year students we are teaching them organically differently. For instance, we are not allowing them to use set-squares and tee-squares in the first year. We are teaching them about visualising ideas, about how to manipulate form, how to swing things round on the paper so they actually have the ability to see the back of an object as well as just a fixed view.

SWG: Do you see drawing is just one component in an activity called 'modelling'?

NMic: Yes. Drawing is a very economical way of modelling, it is the fastest and best way of having a quick idea - a visualisation - of what is in your head and this leads naturally into solid modelling.

SWG: What about this designing activity - the role of drawing in thinking up and manipulating concepts and ideas?
Nhic: The basic tenet, which I suppose we all believe in on the course, is 'if you can’t report on what exists, i.e., you don’t have an investigative vision of the world around you, then you can hardly be expected to report on what doesn’t exist - things that you are pulling out of your head. So objective drawing constantly informs conceptual drawing. We want the students to begin to question the world around them and I think that is fundamental to engineering as well as industrial design. To not just accept that chairs are like this or figures are like that, a casually observed view, but that you can actually investigate it mentally, consciously or subconsciously. It is like watching vegetable soup, every so often a carrot comes up on top and disappears, then a leek comes and unless you try and actually put something down, mark it down and make a decision about it, then you don’t make an analysis you make a subjective judgment.

SWG: Do engineers assume they have been creative until you have shown them otherwise?

NMc: Engineers almost assume that there isn’t any creative act. Many engineers and many students in the past have felt constrained by engineering courses because they didn’t question, didn’t touch on creativity which our new course of necessity will be dwelling on.

SWG: So you would argue for a change in engineering courses?

NMc: Absolutely. Our new course, for example, is a joint venture between the University and the School of Art. We take on the numerate and objective skills of the School of Engineering and we put that together with the cultural skills, which Schools of Art have always been good at. It is curious that Universities have been set up to increase fundamental knowledge while Schools of Art, since the 18th century, have provided a link between industry and art. That is exactly what this course is going to be doing. The classic profile of a student of this course is one who intended to study engineering. They had gone through school, been very numerate and good at the sciences but the school had fought an errant ability in art and this ability in art has been pushed down and marginalised in the subject of engineering. These students still feel there is more to engineering than just being numerate, sitting in front of a computer.

SWG: Do you find yourself having to justify the art contribution?

NMc: No, I think the staff on the main engineering courses are concerned about it because it is seen as a very, very attractive option. They are going to be engineers first and foremost but they are also going to be able to communicate much better. They are going to have an idea of the subject and activity basis of the whole engineering tradition.
rather than just a subject that the University teaches.

SWG: To turn to drawing, what do you teach? How do you raise the ability and awareness particularly of the engineers?

NMc: It's still early days, we have only been operating for two months. We start by reporting an object which they can see, asking them to describe them verbally, by writing about them and in sketch form, then putting those together and seeing how they coincide. Obviously they don't so sketching and verbal descriptions are not adequate, so this is how we introduce the idea of this international language called engineering drawing but we don't call it that, we just call it reporting or communication drawing. We encourage them to think and draw freehand and to use different materials. We have recently introduced ideas of cross-sections as a natural development of ordinary visual drawing because they find they cannot show hollow objects. It develops organically from their current work, not as separate exercises so that they see the need for it. It is curious because from quite disparate drawing abilities one can see a sort of common ground emerging from these students regarding ways of setting out drawings. You can always know that that is the left hand side and that is the right hand side and that is the top and that is the bottom and they can describe it. It is a very simple way of putting across the beginnings of quite a complex subject.

SWG: Is there a desire in students to move towards a norm or do you encourage the development of a personal language?

NMc: What we are looking for initially is a minimum standard that everybody can understand. Everybody can have an accent after they can speak Queens English. But there are different purposes for drawing. You would communicate differently to a Board of Directors than you would to a Production Manager, they want different information, they want it in different way at a different time so we are going to be putting across those means of communication also and again that organically comes out in the way they have been taught. I am sometimes suspicious of those marker pen, artist's impressions in graphics books, in fact I'm very suspicious of those but sometimes that is exactly what is needed for that particular communication. They want something like that, they want to be convinced and because designers do something which is not generally understood there has to be something which is concrete and can create a vision of the future.

SWG: I have come across sketches by famous designers' that are really quite feeble. How do you relate actual drawing strategies to those which you teach?

NMc: I had this confrontation with my students at Belfast a few years ago when I
was teaching them the traditions of good technical drawing. It revolved around an article about Magistretti and how he produced his ideas and showed many typical 'back of the envelope' sketches. The students said "you are teaching us this and yet here is a really successful designer whom we know you admire, how do you put these two things together?" I put them together by the fact that he has been working for one manufacturer for 25 years and they understand his scribbles. He has also gone through, I suppose, 50 years of designing and he understands his scribbles. He has got a very tight control of what he intends and what he infers. He also knows he can trust all those people who take the scribbles to do the right thing because he has a personal relationship with the prototypers and the manufacturer. He knows the shorthand, the shorthand is common both to the manufacturer and the designer.

SWG: Have you ever examined the strategies of sculptors to see how they use drawing?

NMc: I think, fundamentally, they are similar because they are trying to create a model before they commit themselves to a long time in verifying the concept. They tend to be more personally emotive, they don't have to communicate so clearly to others. They tend to work in their own internal shorthand using forms of drawing understandable to them. I have, once or twice, involved sculptors in dealing with projects, particularly when we have, for example, presented furniture or products as sculpture.

Designers have a primary duty to communicate their ideas to others, that is a part of why they are working, they have to convince others that their particular picture is valid and valuable. Also for their own ability to progress the work from a blank page to a working concept they have to be able to make marks which are satisfying and convincing in their own terms. I know designers develop different ways, personal ways of working. I simply developed a way of working which suits me, it's not the same as everyone else's but it influences the way in which the structure comes out at the end.

SWG: Are the teaching strategies you believe to be necessary, particularly for the new course dependent on old values? I'm thinking here of life drawing?

NMc: Well we thought we would do life drawing at some time. I don't mean to be derogatory but it is very traditional and slightly sexist. It provokes certain ways of drawing, just as the marker pens do, but it isn't a form of drawing where accuracy can be closely checked. I think designers are interested in illustration. Take drawing and all that the tradition infers, take illustration in its most holistic form. There probably isn't much difference but it just seems to be that in an Art school there always seems to
be a difference between the illustration that goes on in the graphic design and the
drawing that goes on in print making. I am interested in illustration. I think.

SWG: What about illustration as assisting the seeing of an idea during the process of
conceptualisation?

NMC: I am not sure how creativity takes place or how elegance takes place. There
are two aspects to design - there is the incontrovertible part where it can be seen that
you have answered the problem, you have made the right moves, constructed the right
structure, asked the right questions and at the end of the day whoever you are
presenting it to could not fail to say "well yes that is the correct answer." However
they are also free to say "I dislike the answer you have come up with because it is
inelegant or it is pedestrian or it doesn't lift my spirits." That's the other part, the more
personal part and I tend to leave that up to the students themselves. I've simply got
another point of view and I would say, "in my case I would move that or I would do
this, or have you seen this article or work." What I am trying to do is take in people
who are, to a greater or lesser degree, creative and provide them with a structure for
focusing their creativity and structuring it so that they become professional instead of
amateur creators.

SWG: One difficulty with examining drawing is the diverse nature of the activity of
designing?

NMC: It is an impossibly catholic name. There was a seminar in the Third Eye
Centre a couple of years ago where there were designers on the panel. At one end of
the panel, physically as well as philosophically, there was a fashion designer and at the
other end there was a man who designed Rolls Royce Olympus engines. They really
didn't have much to talk about to each other. I would prefer it to be inclusive rather
than exclusive because by including things you have got the element of chance and the
ability to bring in influences from outside your own notional profession. I think that is
why designers should exist in a large field rather than in a school of technology or as a
special course in a monotechnic.

SWG: How do you reconcile the pressures brought about by the very different
elements of the new course?

NMC: We are bringing two courses together rather than trying to do a bit of both. I
think that by bringing the two courses together under the same teaching team we are
actually going to polarise them beautifully. By getting them to live in one another's
pockets they are going to inform one another but it is also actually going to heighten the
differences rather than make the same person. I think there is a real need in industry,
certainly the design industry is now saying this and they were not saying it four years ago. They now say they want people with a good head on their shoulders, who are creative with ideas, they will always be welcomed by technology. It will be very interesting if we can find technologists who will understand this need. I think that is what is going to happen with these two courses, they will probably talk together. Industrial design will heighten its provocative, spiritual and poetic qualities and it will be informed by the technology of the engineers. It may actually be more aimed at provocation. The engineering course, will be taking on the need for these spiritual qualities but staying very firmly in engineering.
Interview 13

DICK POWELL
Product designer & Partner, Seymour Powell Design Consultancy, London.

RICHARD SEYMOUR
Product designer & Partner, Seymour Powell Design Consultancy, London.

Interviewed: 25.11.1987

SWG: In my interviews to date three major functions for drawing have come to light, these are an observing/recording function; a communicative function and thirdly a personal, manipulative function. Which of these are important to you?

DP: The last. It is the actual process of thinking in which drawing is the most useful. The second would be communicating it to others. We probably don't do as much observational drawing as we ought. Here in this office we believe that drawing and the ability to formally resolve design issues are deeply connected. I mean resolving the way things go together and the way they will work and indeed the actual creative spontaneity of coming up with an idea, something radical, something new, is intrinsically linked with the ability to draw, I can't rationalise that, it's just an observation that people who can draw do it better and people who can't draw don't do it so well.

SWG: Your book 'Presentation Techniques' concentrates on communication but rarely discusses these other issues.

DP: It's a very controversial area. In fact drawing, the role of drawing in art colleges, particularly in the period I was at college was being heavily overtaken by the role of model-making. There was no emphasis put on drawing ability in the product design course by the time I left the RCA which I think was absolutely terrible and I think it has continued to decline since. We find very few graduates coming in here for interviews who are any good at drawing,

RS: It has to be said that if somebody came in with no aptitude to draw whatsoever, it is very unlikely they would get a job here. What Dick means is there are very few people able to draw as well as we do.

DP: I mean I don't pretend to understand the process. We often talk about it but it certainly seems to be the case that people who can draw have an ability to think three-dimensionally and revolve something in their head and that allows them to be able to put it on the paper. We call it an 'onboard CAD-CAM system'. He actually is better at
It than I am. He's got a Polaroid camera up there which just goes 'click' and it comes out on the paper like a photo-copy. We both have this 'on-board CAD-CAM system' where you can draw something like this silly bar of soap and you know what it is going to look like in three dimensions because it is up here in three dimensions.

SWG: Sculptors I have talked to really seem to enjoy the mark-making for its own end, they enjoy the act of drawing. Do you still have time to find drawing really enjoyable?

RS: Absolutely, 100%. When I'm not working I'm drawing, when I'm relaxing I'm drawing. I draw the kids.

DP: It's less true of me though. I used to get more pleasure from the drawing. We used to do more finished rendering here than we do now. Our main task in life is designing and drawing is a tool we use to help us design things but there was a time, before I wrote the book in fact, when the business of drawing absolutely fascinated me. I was really into the process of drawing more than anything else and now it is much more of a tool. I really only draw, outside of the office, when I go on holiday. water-colours and things, the actual business of drawing is totally subservient now to the business of design.

SWG: In that case, how should design education approach this area of teaching drawing.

DP: This is a difficult question. I feel that there is certainly a strong demand in the design world, both for people who can draw and who are good at manipulating form and this other type of being who is a good designer but not necessarily able to draw. Now that kind of person is often very good at other things, like sorting out technical problems and resolving something technically or resolving it in the way it goes together, or its construction or something like that. We need those kinds of people as well. I don't think all designers need to be this way but I would say that the balance is somewhat upset, we should encourage more people from an art background. I mean the art has gone out of product design to a degree. We need more people who produce silly radio sets like colostomy bags! I don't mean that. I mean people who have a skill and an ability to resolve things formally and make things look exciting. In my case I was always interested in drawing so it was never a problem with me. I wanted to be able to draw when I was at Foundation course and make things look real, that was more interesting to me. We did a lot of life drawing.

RS: The wonderful thing about drawing, as opposed to rendering, is that you can generate a spiritual conception of what you are doing, you can erect the spirit of

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something in a sketch. I mean, throughout history the people who have been the very, very, finest drawers have been the people who have been able to conjure the essence of something with the most incredible economy of line and description. It goes beyond the ability of being able to take what is there and put it down - like a life drawing; no, not like a life drawing exactly, when you are drawing a tree or something like that, not merely recording, it's what springs from within.

DP: The question is, does the activity of, say, life drawing; the activity of observing and recording, actually improve your skills at the other end of the spectrum. Yes, I would say that it does. I think that the more you draw, the better you get at drawing and I also believe that you can teach anybody to draw. Drawing is just a question of the way you look at things not something that is skill in your hands. It's a skill in your head and I think that there are people who can be nurtured very easily and turned into something.

RS: We were talking about music before you arrived, and had faced the fact that most people can pick it up, less people can be very, very good at it, but it is my belief that you do need some sort of connection, a system of synapses between eye, brain and arm to actually be able to do it very well. I think drawing and music are very similar in that respect. These items in these drawings cannot be made, they took only five minutes, but they encapsulate the essence of what you are trying to achieve.

DP: That is something you can only do with drawing, you can't make a model of it, you can't even describe it with words, you get an instant concept of what's going. That's why when we write reports we go through the motions because they pay you money for a report but at the end of the day you produce a drawing or six drawings, whatever, and they say, 'yes, yes, I see what you mean.' as opposed to 'what do you mean by this?'.

SWG: With regard to those motorcycle elevations on the wall, how much of that idea was already in your head before the image was put down and how much was happy chance of the marks, washes and media etc?

RS: That depends on the person who is doing it. With me it's usually mostly there already, the instant before I do it. Some other people use the wandering pen to actually help them establish things, but I think you get, for as many people you ask, you get as many different answers.

DP: I think Richard is unusual, I have never met anybody else who can do it like that, everybody else I know does it the way I do it which is evolution on the paper.
RS: On the basis of what Dick's just said there are very, very few people in the
world who would, I suspect, be able to conceive it all in their head and have no
drawing ability whatsoever. I think it would stop there a lot of the time because they
would hit a stone wall of incommunication, both with themselves, but more importantly
with the outside world. They wouldn't be able to express themselves.

DP: We must be careful here, because you will find in your research, if you
haven't already, that those who can draw will say it's very important and those who
can't will say it isn't.

RS: Well it's like me. I'm partly colour-blind, I make light of it. People say
'How can you be a designer and be colour-blind' and then the inevitable 'how do you
see red?!' Somebody that has been deaf from birth doesn't miss hearing because they
have no real concept of it, the difference is the people who can't draw as opposed to
people that can draw. They may actually believe it doesn't inhibit them at all, they may
actually be reacting against it because they feel they can't do it, like 'Who needs to learn
a musical instrument anyway?'

DP: That's definitely true, people who can't do it will slag people who can, but
they will also say it's not important to their particular brand of creativity. There may be
some truth in everybody's brand of creativity being driven by something different. But
we are still hard down on the side that you are a more creative person if you can draw
than if you cannot because you can have this conversation with yourself, you can
express your ideas to others and you can organise your thoughts better.

SWG: When you are styling a product for example, how does drawing work for
you. Is it just an evolutionary process, or are you learning a lot about the potential of
the form?

RS: Take that drawing of soap bar shapes, you move a line a millimetre and it
becomes a different object. Dick and I have never designed soap before. Dick and I
will not be designing soap again!

Every single sketch, drawing, anything I ever do, I learn something from, whether it is
a tiny thing or a lot. But there is another thing that goes beyond it, it is the most
immensely gratifying thing you can imagine. It gives me job satisfaction in what I
produce, to sit back and to do something, occasionally I do something I like, I get an
immense amount of pleasure out of it - 'gosh, it really is what I want to say.' But I
forget it occasionally, I don't mean I forget to draw but you forget - you know people
come up and will say 'hell, I wish I could do that'. I think you can teach almost
anybody to render, I don't think it's nearly as easy to teach anybody to draw. I mean
you can help them on the process and hence the book.

SWG: Has your drawing style changed or condensed over the years and why?

RS: My drawing style condensed when I was 18.

DP: We have a way in this office now where we tend to draw everything the same way because it is very economical and very quick to do.

RS: We render, we don't draw it.

SWG: The drawings on that sheet there. They might say more to you than comes over in the communication.

RS: That's an interesting one you pointed out because that's a Richard and Dick's shorthand. When Dick and I work together shorthand is a very good way of describing it, because that is precisely what that is. It's a more refined language than this.

SWG: And is that assisted by natural language, an articulation in words?

RS: Of course it is, and yes, it's a refined language. It's a very high order of language. If you put all the components together it is fantastic, you know it's like one of those bursts of information you get from a satellite - a million bits crammed into half a second. It's very sophisticated and shows how much you can communicate. You've got all these concurrent tracks; you know, the gesture track, the eye movement track, etc., etc.

SWG: Is the consideration of these issues important in design education? Ought we to develop abilities with this sort of sketching?

RS: Sketch books are always pushed around and I would have thought that's it. The trouble is with the way it works. In education people say 'Look you guys, sketchbooks are really important to get you into college, they are all going to be looking at sketchbooks'. So students panic because they haven't done a sketchbook and set to and scribble out a post-generative series of drawings. I always used a sketchbook as a sketchbook - it was not precious but we see a lot of rubbish that pretends to be preparatory drawings from students. You can tell the real drawings, the developmental ones.

DP: They are really important. We like to have a look at the way they work.
RS: Yes we do, but I'm sorry to say I tend to look at the end product more than the way in which it has been done.

SWG: Do your own backgrounds in product design and graphics have any influence on this?

RS: Well I trained as a graphic designer and Dick studied product design but people don't fit so comfortably into their little niches. I am a three-dimensional designer, I just happen to do graphic design, but you must ask Dick.

DP: You don't have to study product design to be a product designer.

RS: But more to the point, my brain has always worked in a three-dimensional manner, even in advertising, I always thought three dimensional in that. As I said to somebody the week before last, don't use me or us for that matter as examples of our breed, we are not. We are very unusual, we work in a very unusual way and we are one of the few design teams in product design anywhere in the world. It doesn't exist in product design - two guys working together most of the time. It doesn't work like that.

DP: If you go to another group like Roberts-Weaver you will find that Barry Weaver and Joss Roberts don't actually work together at all. They each have their own specialism or in some cases you'll see other groups where each has his own client

RS: If we had both trained at the same college, done the same sort of things, it is very unlikely that we could be working in this way. It is because we have come different routes and taken different perspectives on things that it continues to be interesting. If we had done the same things and worked in the same way, it would get very tedious very quickly.

Anyway, to return to drawing, I personally make a very strong distinction between rendering and drawing, a very strong one. I very rarely do a rendering. If you were to look at what we do we have a skill when it is necessary, as Dick has already explained, to produce a series of renderings where to anything but the most tutored eye anybody would find it almost impossible to differentiate from which hand each one of the things came. But I virtually always work freehand, that's the way I am. Others work constantly with rulers and guides and things like that, not because one is better than the other, it's just the different ways in which we do it, if you want absolute passionate supporters of drawing, the importance of drawing, what drawing is all about, you probably couldn't do better than with either of us, we both feel very strongly about it.
DP: For a student of design, drawing is probably the most important thing you can do. When I used to teach a lot I would say to people whatever you do, be it product design or graphic design, or whatever, if you are trying to function and make a living the one thing you can do, which the person you are selling to cannot, is draw. That is particularly true in our business. When we go into a big company like --- (name removed) they've got marketing people, sales people, engineers, plastics technologists, electronics, all these blokes. The one thing they don't have is someone who can draw so you've got a terrific weapon. You sit down at a table at a meeting and say 'oh, we can do it like this' and as soon as you start to do it they say 'oh, how do you that'. I would imagine, even if you are a textile designer selling to a textile company, you are worth buying because he hasn't got that.

RS: We occasionally get involved in on-the-spot creativity, things; where you get designers and other people together and you are brain-storming something. It is at that point that you often find that you have got the most enormous impact because it is one thing to look at something after it has been done but the thing that seems to fascinate people who can't draw, more than anything else, is watching someone go da di da 'look at that'.

DP: You've only got to go past those portrait artist in the tourist spots to see the crowds, the enormous general interest in people who can draw. But the most interesting thing on these occasions is that many people are coming up with ideas and you can not only draw them but you also conceptualise them in the same instant.

RS: It takes on a form.

DP: Someone will say what about an idea for a saucepan that does this and that and you say 'what do you mean. like this?' and suddenly you present them with a picture of it.

SWG: Do you like looking at other designers' drawings - to get inside their heads?

DP: Yes, we both do. There is a certain amount of professional interest - is he any good?!

RS: But as for getting inside their head, it depends, very often if you look at sketches you'll find they are randomised, they are not actually a flow of consciousness. But yes, it is always interesting to see the different ways people work in that respect.

SWG: How does drawing help you on more technical aspects, the job you are doing, the product design, I assume the work isn't all styling?
DP: Where drawing skill helps most is the onboard CAD-CAM again. It helps if you've got a very complicated bit of moulding like for example the jug kettle. You can visualise not only the product but the tool that makes it. You can see where the undercuts are and you can configure it in your head. We sit down here with injection moulding problems, say working out some catch release or something. You scribble and the drawing helps you to understand, especially when you've got a core going through another core and two bits coming together, it's a very complicated three-dimensional puzzle.

RS: How could you do that without drawing?

SWG: You would have to model it in three dimensions.

RS: And the other thing is, supposing you had the sort of brain that could actually keep that, you know the sort of thing you read in the Guinness book of records of the guy that can keep five billion names or dates in his head. Suppose you could actually materialise on your onboard CADCAM this fabulously complicated component - how the heck do you get it out. I mean, in what form does it come out. It is very unlikely you are going to be able to chisel it out. There has to be an intermediate step which is putting lines on paper.

DP: The drawing is the equivalent of the computer driving the robot arm, cutting out the block of polystyrene. The brain is driving the arm and showing it on paper, which it can do quicker than wielding a tool. We do use modelling in that sense, but it depends on what you are doing. If we are doing a hair dryer or something you tend to make models quite early on. They are not really sketch-models. We personally don't pick up a block of polystyrene and go into the workshop with it. Perhaps we ought to do that and it's quite nice to do it, but somehow one becomes immune in the sense that our time is terribly valuable. We are actually very much better off doing something else and setting a student to do a model and you tell them they've done it wrong, do it this way. It's quicker for us, than actually going and doing it ourselves.

SWG: Do you have a philosophy of design that embraces production, styling, creativity etc?

DP: Take someone like Sottsass when he kicked off, trying desperately to come to terms with the new form of expression, anti-production, trying to produce things in a certain way. A massive dilemma set in, trying to communicate in a different way and yet actually flying in the face of productionising the things. We are not quite lumbered with the same sort of problems here in as much as productionising of things. Consumerism is the raison d'être. That is what it is all about. We don't see styling as...
a dirty word but styling is very rarely the total component of what we are doing. We
don’t take the view of design as an added value, it’s an integral part of the whole of the
thing, the article is better for the whole process of design at all stages of the game. We
are very rarely asked to wrap a skin around something, we are much more likely to be
asked to completely change the thing on behalf of the client. We are trying to produce
something that is going to sell better, perform better, be more attractive.

SWG: Do you also feel, deep down, that you are furthering the language of visual
form, you are doing something intellectual about twentieth century design as well as
just getting things that sell?

RS: Yes, I do, I think that we are improving the quality of life, by allowing people
to be able to have a choice about what they surround themselves with. I mean, you can
argue that the world doesn’t need a hairdryer but if people want hairdryers they should
have a choice of different hairdryers.

SWG: Do you do any soul-searching on the form of hairdryers or do you just refer
to marketing surveys?

RS: We never look at marketing surveys.

DP: Everything we do in that sense is totally intuitive and from the heart. It’s
‘what should a hairdryer look like - it could look like this’.

RS: Yes, we do do a lot of soul-searching in that respect. I always fight shy of
words like philosophy, deep thinking, consideration, etc., because I think a lot of the
time people pooh-pooh the reflex of design where they believe that they are searching
for some deeper inner meaning of all this. In fact often the reflex reaction, the
immediate reaction is often the right one. I am not saying it always is but it very often
can be because an immense amount of pre-processing has already gone on inside the
head without you realising. Because something comes out in a reflex manner or in an
emotional manner doesn’t mean it’s trivial and superficial, it can often be completely the
opposite.

DP: We are often very self-derogatory in that sense because we will come up with
ideas of something, look at them and evaluate them against our own screen and we
might glibly call that post rationalising, but of course it isn’t. What you are actually
doing is coming up with an idea intuitively and then looking for facts and factors which
support what you have done.

RS: It may have been prerationalised, it’s just that it was subconsciously

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prerationalised a lot of the time. You are doing that all the time in life, you are subconsciously prejudging and prerationalising, the brain is fantastically sophisticated in doing it. It can assess a dangerous situation in very, very small fractions of a second and make your body respond in a certain way.

DP: If you are thinking of the subconscious, design activity is like a radar scanner where you get a lot of information coming in from varying and disparate sources, be it the society, art, architecture, or the market or wherever it is and all that is churned up and distilled within yourself. It comes out as your design and creative process. I actually think the creative process is better for being more intuitive. Designers who sit down and write a manifesto and then rationalise what they are going to do before they do it, actually put a barrier, limit the scope of their creativity, by so doing. My belief is that you do it better by trusting your own ability, do it and then you can find support for what you have done, find reasons for what you have done after you have done it. It is not a popular view at all but certainly it is the way I think we operate here, but then inevitably you get criticised for it.

SWG: To what extent is ego responsible for your decisions?

DP: It's very nice to be appreciated. I hope that in fifty years time people will look back at some of the things that we have done and say 'that's 1988, 1987', and there is something about it which makes it right for its time. It's always unpleasant when people say they don't care for something, it's true in any walk of life isn't it?

RS: The trick is to be able to determine what is a natural rational reaction and, returning to drawing, how much of it is jealousy. A section of all this which you haven't considered is the negative reaction a drawing can actually produce. It is quite an interesting one, like the negative reaction that a concert pianist can produce in some people, see what I mean, 'I wish I could do that'.

SWG: Which designers do you admire - who do you think gets it right?

RS: I can't think of a single designer who gets it absolutely right every time. There are lots of people we admire, that's a different thing, we don't have design heroes.

DP: We admire Giugiaro, and certainly I would admire somebody like Sottsass. We often say it's a shame there aren't any younger design groups springing up these days. What's happening to them all? You do occasionally get people like Ross Lovegrove, for example. He is incredibly single-track, dedicated and his belief is absolutely unshakeable and he still has something of what I think we had when we left...
College, you know, we are going to take on the world. I like to see that unshakeable faith in people. You can admire someone for that. You might not agree with what they do.

RS: But it is incidental that they are designers, what you are admiring is the attitude, it is not their ability. The nearest I can get to a designer who I really do admire as a designer is Mary Lewis. She is an exceptionally talented, articulate, clever woman, who consistently produces extremely good looking stuff that appeals to levels beyond mere frill, it's got guts, it's got punch to it, it's different, it changes your attitude to things, almost because of the massive impact it has had on so many different areas. That's what I like. I like the breadth of the impact it has had on so many different things.

DP: Then on the other side of the scale you get people who are full of philosophy and incredibly interesting to listen to and to talk to about design and all the rest of it, but what they produce is completely off the wall and you think you can't really equate this intelligent thought process with what these guys are designing.

RS: I hate most of Sottsass's work. I find it mindless, not mindless, meaningless jangle.

DP: There is a lot of ghastly stuff but it is thought provoking. I was talking about this to a client the other day. It's a path-finding activity, it's like the path-finders in the war that led the Lancasters into Berlin, you know somebody out there has got to be flying ahead and dropping flares all over the place. They might drop a flare there, a flare there, and a flare there. The main fleet coming behind could sort of look at them and say 'that's an interesting target, that's got a lot of promise'. We are all heavily influenced by what's happening there but it doesn't mean you make a hairdryer look like that. The colour, we have been impressed by the colours of things, but it's the approach of post-modernism, the approach that was born out of the product identity debate about what things should look like.

SWG: Would you say you strive for elegance in your designs?

RS: It's an interesting one this. Pertinence, rather than elegance. No-one would call this, little handset elegant, you wouldn't say it was elegant. Exciting, appropriate perhaps, but I wouldn't call it elegant. When I think of elegance I think of continuous, smooth forms, organic forms, I think of things that are lacking in unnecessary protrusions. Things that conform to classical Greek concepts of proportion, I think of things like that. There is no attempt, unless it is important in our understanding, to make something elegant. We don't believe that military communication equipment
should be elegant. It should say I'm good looking and I'm tough and I'm better than the opposition, it should not say I'm elegant. I mean a racehorse should be elegant - a dragster or a pro-stocker should not be elegant.

DP: This motorbike shouldn't be elegant, it would be all wrong if it was an elegant motorcycle, it would be like the Queen's carriage.

RS: I believe you can produce an elegant hatchet, an elegant hammer, but you've got to analyse very carefully the personality that you are trying to put forward.

DP: I think know what you mean. I just wouldn't use the word elegance. I have been reading Kenneth Clark who disputed the typewriter could ever be made beautiful, there was no way you could ever make a beautiful typewriter.

RS: Beauty and elegance are two different things.

DP: That's what I am saying, I think there is a beauty, again I'm struggling to find words but there is a beauty about the handset which is to do with the way in which it is appropriate for what it has to do. A natural elegance, a formal balance. I would say there is a formal balance. The things we do don't look uncomfortable, they look relaxed for what they are. Appropriate is a better word. Appropriateness is absolutely right. There is not enough concern in product design with making things look right. There is too much concern with making it different, innovative or profound. We call it desirability, factor X. We try to make something that makes people say 'I don't know what it is but I want it. '

RS: I had a discussion with somebody the other day about a film and he said 'when I go to see a film I like to be challenged'. To put through the mill a bit and have ones thoughts turned upside down'. When I go I like to see lots of hardware! I like to see films such as Top Gun. Getting back to the point, we are not trying to produce things that challenge the whole precept of modern life. What we are doing is producing things which are fitting within the comprehension of the consumer within their terms of reference. Things that they find exciting, desirable. We are not trying to take it so far ahead that there is an abyss between what we produce and the consumer. We are producing consumer products, we are not producing Fine Art.

SWG: What is your opinion of the 'consumer' ?

RS: They believe that they are being horribly manipulated. The designer should feed in information at ground level so that design becomes far more all-pervading within the educational system. People should be exposed to it as they come up through
the ranks. Secondly you plough your lonely furrow like Terence Conran and you try to affect public taste by providing them with things that are, questionably, superior.

DP: I think it is happening anyway. The public perception of design has been raised considerably over the last few years. We sometimes find within industry a response saying 'we know that we need design - we don't really know what it is - but we know that we need it because our competitors have got it'.

RS: It's 'designers virus', you know, 'we'd better have it I suppose'. 'We might as well get it over with'.

SWG: Is British industry as bad as people say?

RS: No it's worse. Fifty percent of our work is with foreign clients. You haven't asked about the Japanese yet.

SWG: What about the Japanese?!

RS: Ah, I'm glad you asked me that. We like working under companies and with companies whose marketing approach is shaped by the dictates of their Japanese lords and masters because they're consumerists gone mad. We like that. It's a real 'let there be light' philosophy. If somebody comes up from British industry they usually say 'Can you just design this small part to go here'. The Japanese approach is to say 'Here is factory.... here is million people.... here is grillion yen - go and take on the world!' It's a shame it's not the British who are doing it.

SWG: Do you not find the responsibility of such scope daunting?

DP: Well, generally we find that is what people pay us for. They are paying us for what we think. It is amazing how we can go into these megacorporations, at the highest level. We are not wearing suits or sitting in an A.I.D.-type office with chrome furniture and Breuer chairs everywhere. You know what I mean. But people seem to want to know what we think. It is nice.

RS: More and more, people pay us just for our opinion - not even for the work, just for our opinions.

DP: And in fact the more that we do, the better we get, the more on-the-ball our opinions are, because we are doing it. We have both written books and I want to write a book about design - not about drawing - and one day I'll probably get round to doing it. People will probably look at you in a different way then. We feel we have no right
to talk about it until we have done it. Half the problem is there are too many people out there who go on about it but don't actually do it. I feel that people like Giugiaro have the right because he's done it and he has changed the world.
Interview 14

ALAN WILLIAMS

Industrial Designer / Director, David Carter Associates (DCA), Warwick.

Interviewed: 2.11.1987

SWG: I know that you have a background in Fine Art and one area that I am interested in is how these skills relate to the very commercial and technical world of Industrial design. More particularly I am concerned about the role of drawing in the manipulation and communication of ideas.

AW: Yes, communication; that perhaps indicates to me the best way to present a drawing. It is not a strategy suited to finding a solution to my problem: I have got to be able to start off - even if it is with a burnt stick on a piece of paper - to scribe out an idea, maybe how two mouldings relate together. I can't assess that in any other way apart from continuously sketching certain sections of it, set out on a piece of paper, defining the idea until I have got a solution. From my viewpoint it is the simplest sort of drawing. If I go and see people and talk about potential problems, I always end up with a pencil in my hand, drawing the problem.

SWG: Does it assist you in the conceptual side of the thought, i.e. do you have the thought first and then seek to communicate it on paper. Or do you find sometimes that the act of drawing is actually fundamental in the conceptualisation?

AW: It is a completely interactive process. You have an idea, very often the idea is so feeble and so misty it is a bit like looking through the wrong end of a telescope. To bring it into focus you have got to scribble and scribble and refine it. Finally the idea starts to flow and join together on the surface of the paper. It is a development process. With a pencil in my hand I feel whole and I am only half a person without it - I am restricted to speaking about the design. For me it is a means of improving the design.

SWG: You mentioned scribbling just then.

AW: Yes, the most appalling things to anybody else. In a discussion this morning we were talking about the interiors of trains and I was using the roughest sketches; typical 'back of a fag-packet, type of drawing but it was worth a thousand words.

SWG: Is there any purpose in teaching that type of work in design colleges? There are many books on presentation but we seem to almost shelter students from the activity of drawing whilst thinking.
AW: In a way I am almost convinced that anybody can involve themselves in that activity, in the sketching to clarify one's own ideas rather than sketching to communicate. I think that by scratching away on a piece of paper the ideas expand. I think that people get inhibited when they are called upon to make a drawing to communicate. That is where you have to be trained and your technique smoothed out and made acceptable but I think principally anybody can sketch, the kids will do it at home, it is a natural thing.

SWG: Do you think it has been stifled out of a lot of people?

AW: It is difficult to say. The temptation is to say yes it has been stifled out because of the over-riding requirement for academic attainment. My father used to say "any fool can draw" and yes I think there is an element of it being a non-academic, very basic function but for all that I think it is fundamentally important.

SWG: Could it be replaced by natural language, is there a grammar to replace it?

AW: No I don't believe that there is. You probably had the exercise at school, I know that I did, when you were told to describe in words, a woodscrew. You write three pages of rubbish whereas a ten-second fiddle with a pencil tells all the story.

SWG: You are obviously in the position of employing graduates from art colleges and universities. With particular reference to their graphic work what do you look for? What would be the key for you to say "this person has got it"?

AW: Nearly everybody that comes to see us brings a portfolio. Of the few people that I see, I like to see their rough workbooks, their sketch books etc., because in a way that is where the ideas are given birth to. I think that presentation drawings can be larded and laboured over a long period of time. OK it is important to be able to give people presentation drawings but to get the ideas on paper, to satisfy one's own requirements, is much more important. I tend to look at the scrawling, the sketches. The better those are of course, the quicker the ideas are able to come about. Perhaps in certain circumstances quantity of sketching or scrawling is an indication of a poor or illogical process of thinking, but it can reveal a way of using a pencil as a tool to uncover ideas. Few people can actually sit down and draw something that they have imagined. It is a natural way of developing ideas. One can usually identify by looking at somebody's scrawlings how hard it is for them to get any ideas. if there is a flow of ideas the sketches, the drawings seem to indicate the lucidity of thinking.

It may well be that some people find it difficult to communicate in discussion or in written form. I am not a fluent writer, I am much more at ease with a pencil. So I
think that very often there are great frustrations in people who are potentially very creative and they are channelled into an area where scribbling is somehow frowned upon. I think there may well be a systematic method of teaching people how to scribble and therefore express their ideas, I don't know. It is a thought and it would be important to me, it would be an interesting way of approaching the subject.

SWG: Your background was in sculpture and the fine arts.

AW: Yes, my NDD (National Diploma in Design) course - the old NDD course - was very much a classical way of teaching people to draw. We had to sit down and draw the Elgin Marbles and the like, various naked women and also a lot of architectural drawing based on an understanding of classical proportion. Basically the old fashioned way of teaching people how to do it.

SWG: What effect has this background had on your involvement with the technological world of design?

AW: My family were engineers but I was the only 'artistic' one. I could draw and I could paint and it was mildly interesting to members of my family but it wasn't engineering. It wasn't the sort of thing that engineers did. Although, in retrospect, I suspect that my father did a lot of scribbling in little notebooks at certain times. When I went to Art School I accepted the concept of being trained as an artist, probably because I didn't know anything better. Half-way through my training, purely by accident, I became involved in some detailing of some new studios. Some of the engineering background had rubbed off and I could do technical drawings as well which was quite unique. So I was able to combine the facility of being able to draw things and express ideas in an artistic way as well as being able to communicate through orthographic projection. As it has gone on that relationship has been made stronger and indeed I would think I am now more of an engineer than I am a designer. I would like to think that sometime in the near future I could get back to the things which are slightly looser.

SWG: Should the education of engineers therefore develop a more profound capability with drawing?

AW: I suppose it would be a help but in a way don't you think that engineers who were given an old-fashioned classical training did this - I mean people like Brunel and Telford? Maybe the engineering trade is so compartmentalised and specialised there is no room for this expression any more. I mean, I expect that Civil Engineers are taught to draw and appreciate forms of bridges and things but I couldn't be sure to what extent that still goes on. Certainly product engineers, while they may well be aware of the importance of design, are not taught the golden section or other aspects of proportion.
SWG: To turn to the computer revolution. How do you see that affecting the creative role in design consultancies?

AW: Well, as yet I don't see it affecting the nature of the things we create or the way we create them. I think many people are quite happy, in fact happier, to work with a pencil rather than do it on a computer. My feeling is that it will come as equipment becomes more flexible, the learning curves will become shorter. We have thought for a long time about so-called computer aided design and how nice it would be to be able to put forms on paper which are mathematically correct but if you think about it the form has to be dreamt up first before you can mathematically correct it. So in a way you've got the chicken before the egg. Whether there will be a time when you can say you have created an egg that's been done by a computer from my ideas rather than scratched out on a piece of paper, I don't know. After all, it is only an extension of your pencil and pad.

SWG: You believe it can be as creative as pencil and pad, given time?

AW: Given time.

SWG: The DCA brochure outlines the variety of tasks that go on here. Does drawing only play a role in product styling and product conceptualisation or does drawing form an important medium for engineers, software designers and industrial designers throughout the whole organisation?

AW: It's a whole. Without drawing it would all fall apart and disappear. I mean, if you talk to the accountants, and I'm not saying they all do it, but increasingly you will be shown curves on a piece of paper rather than sets of figures. It helps an understanding of the accounting process. Engineers will do it. They draw up performance. They draw curves, it's sketching, it is not measured. It is an indication to them. They have communicated their feelings about performance to you via a sketch or a graph and you are immediately with them. It doesn't have to be measured out or plotted the symbol - or the relative position of that curve on the symbol - lets you say "yes, I understand that".

SWG: Do you still find time for recreational drawing?

AW: Yes, I draw quite a lot, I keep a pad in my car. I draw birds and stones. I think your level of inquisitiveness drops off if you are not constantly looking and thinking and sketching about a notion or a thought. Inquisitiveness is absolutely vital to a designer. If you lose interest you might as well pack it all in.
SWG: How does one inspire inquisitiveness in students?

AW: Now there's a question, I don't know how you do it, there are no formats. Getting back to my own school days, I think our best teacher, the best for me anyway was our teacher of music. At that time I hated music, listening to concertos on a beaten-up Pye radio. He used to launch into what I suppose were rather eccentric explanations of certain passages and he made it live by putting himself into the composer's seat and acting out certain parts. Now whether you can convert that sort of thing into what we're talking about I don't know. It is a personality thing... it sounds corny but I believe, I still believe that teachers are born, and not trained. If the spark is there then I think that the teacher should be sensitive enough to be able to draw it from a pupil by giving helpful criticism. This should always be constructive and never destructive, never even generally destructive, You have to turn a blind eye to the quirkiness of technique, perhaps, if within the technique on the paper you see it is giving expression to something which you recognise, that is enough.

SWG: Are designers also born and not made, the good ones anyway?

AW: Yes I think so, I think that you often meet young lads who are obviously dead keen and the work explodes off the paper. You can tell. You can spot it.

SWG: Are there any designers that you would point to as being people you respect in terms of using drawing for this creative activity?

AW: They are probably all dead I think.

SWG: Does that mean this particular skill is dying out - that design has become too slick?

AW: I don't know. If I am perfectly frank I don't know how many designers operate. I admire the finished work. I think generally speaking they are Italian but I think that one is somehow mesmerised in some romantic way by the fact that they are Italian, and Italy is a nice place to be and people get to be called maestro and all that kind of thing, I don't know.

SWG: People like Mario Bellini?

AW: I think I am right in saying that he was trained as an architect and I think the intellectual content is important. In the race to get trained there doesn't seem to be any room for the consideration of social issues. I think in architecture one has to be aware of those issues and I think that sort of training would help engineers and designers.
would be great if it could be introduced into the training of designers. You could give them a broader awareness. I am not crying for methodology, I am appealing for a fuller appreciation of wider issues.

SWG: Architecture is a mature profession, do you consider product design to have reached a maturity yet.

AW: I don't know. I have a feeling that design in certain instances started out being taught as architecture is. I suppose the Bauhaus was a leg of the architectural school, and that was a great benefit. I think a lot of the Italian designers are trained as architects, their appreciation is much broader and you can see it in the way they write, it is a more global style of thinking, wider, a clearer thought.
### Appendix II

**Design briefs used in the ROCOCO Project**

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<td>Studies 1&amp;3, Phase One</td>
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<td>Brief C</td>
<td>'Duracell' product</td>
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<td>Brief G</td>
<td>Garden leaf collector</td>
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**Brief A  Body temperature measuring device**

A company with expertise in electronic components has decided to begin manufacturing and marketing its own consumer products. The management board feel that with their first venture they must be cautious in the size and complexity of the venture. Following a recent incident in his home, when the family mercury thermometer was broken, the Managing Director has suggested that the company's first product might be a method of measuring body temperature so as to determine a person's state of health. It should be safe to use and simple to operate.

As the newest members of the design team, without preconceived ideas about the company practices, you are invited to examine the problem; generate product design ideas for both the technological systems and the total product concept; make recommendations for the manufacture, materials and assembly; convey methods of use; suggest suitable packaging and devise a suitable name.

The company Board have not previously had any experience of the way in which a product designer works so it is particularly important that one main concept is singled out from the idea development sheets and is clearly presented.

**Brief B  Portable powered barbecue grill**

The Directors of a company specialising in the manufacture of sheet metal products have become aware of the growing number of cast iron and sheet metal barbecue products now on the market having been imported from Far Eastern countries. The smaller versions of these products are often taken on holiday, by caravanners and campers, boxed in their original packaging.

The Directors feel that sufficient demand exists for an up-market barbecue offering a rotating spit facility. A raised stand is seen as an important element as many potential users will be in the older age groups. Such a product would need to be folded or dismantled and transported - probably inside a caravan or the boot of a car. Compact storage at home should also be a factor.

Your company has been approached for ideas and a major design proposal based on sheet metal and lightweight metal rod for an outdoor, powered barbecue grill. You are asked to consider this area together with the implicit problems and to develop a response to it. Your client wishes to see a fairly detailed proposal by the deadline. Consider materials, production, marketing and technological details in your development.

*Appendix II  Design briefs used in the ROCOCO project*
Brief C  ‘Duracell’ product

The firm of Duracell have attempted to raise their profile in the market place through the provision of design conscious products for which their batteries provide the power. The Durabeam torch is one such example.

The company is now looking for other products to extend this design image while promoting the purchase of Duracell batteries.

You are asked to propose a range of ideas and to develop one battery-powered product which fulfils this objective. The company do not wish to retain any elements of their existing ‘house style’ and therefore these considerations will be expected along with those of manufacturing, materials, assembly, costing and marketing.

Brief D  Savings box

Your client, a well known toy manufacturer, has come to an arrangement with a major Building Society in an attempt to get children to save more money. They have jointly decided that they will provide any investing family with a free money box. The have come to your design team for ideas for the design of this money box and are particularly interested in exploiting the movement of noise associated with coins. They do not want mere animal shapes, cartoon characters etc. They have not ruled out simple electronics if you think this is advantageous.

You are asked to consider this area together with the implicit problems and to develop a response to it. Your client wishes to see a fairly detailed proposal by the deadline. Consider materials, production, marketing, human factors and technological details in your development.

Brief E  Childrens flask

Many large High Street multiples such as Boots or British Home Stores retail a wide range of products for the preparation and storage of foodstuffs. However, the small range of containers for transporting and maintaining drinks and other liquid-based foodstuffs in a hot or cold state is now dated, unattractive and inappropriate, especially to the younger age groups.

With the heightened awareness of diet and recent reductions in lunch services by schools the client wishes to enter the market with a rugged and efficient portable container for soups, drinks, etc. It should be acceptable to school children of both sexes.

Appendix II  Design briefs used in the ROCOCO project
You are asked to consider this area together with the implicit problems and to develop a response to it. Your client wishes to see a fairly detailed proposal by the deadline. Consider materials, production, marketing, human factors and technological details in your development.

**Brief F  Ironing board**

The design of domestic steam irons has received great attention in recent years. So too has the technology of fabric and garment construction. However, the activity of ironing is still largely unpleasant, partly due to the poor design of ironing boards. Your client is responsible for product innovation in a light engineering company who have experience of high quality construction and finishing in metals and plastics. They have approached your design team for a suitable replacement for the domestic ironing board that will be acceptable to the mass market.

You are asked to consider this area together with the implicit problems and to develop a response to it. Your client wishes to see a fairly detailed proposal by the deadline. Consider materials, production, marketing, human factors and technological details in your development.

**Brief G  Garden leaf collector**

Fallen leaves represent an excellent potential source of compost such as leaf mould. However, the gathering and processing of leaves represents such a difficult procedure that many gardeners or smallholders tend to ignore this resource and instead purchase alternative products for soil improvement. The client wishes your design team to consider the collecting of dead leaves. The client, in this instance, is a large manufacturer of hand and powered garden products with capabilities to form a wide range of materials.

You are asked to consider this area together with the implicit problems and to develop a response to it. Your client wishes to see a fairly detailed proposal by the deadline. Consider materials, production, marketing, human factors and technological details in your development.

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*Appendix II  Design briefs used in the ROCOCO project*
ROCCOCO Phase One drawing sheets

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PHASE 1
Study 3
Sheet 1
Phase 1
Study 4
Sheet 1
PHASE 1
STUDY 5
SHEET 4
PHASE 1
STUDY 6
SHEET 1
Appendix IV

AGA data capture sheets

1. Phase One - Graphic Acts by 5 minute time band
2. Phase Two - Graphic Acts by 5 minute time band
3. Phase One - Distribution of SGAs over sketches
4. Phase Two - Distribution of SGAs over sketches
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<td>WGA 4 DGA 9</td>
<td>48</td>
<td></td>
<td>48</td>
<td></td>
<td></td>
<td>WGA 3</td>
<td></td>
</tr>
<tr>
<td>WGA 4 DGA 2</td>
<td>53</td>
<td></td>
<td>53</td>
<td></td>
<td></td>
<td>WGA 0</td>
<td></td>
</tr>
</tbody>
</table>

Subject WGA: 54
Subject DGA: 120

Shared drawings: 1.5 1.27 1.6 1.2 1.40 2.8 2.9 2.27 2.16 2.11 2.10 2.2 3.3 2.5

Total drawings produced: 85
Data Sheet 2:

**Drawing and Designing 97**

**Drawing Graphic Acts (DGAs)** distributed across drawings

<table>
<thead>
<tr>
<th>Subject A</th>
<th>Subject B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 3 drawings for DGA production</td>
<td>No of Drawings comprising 3 or less DGAs</td>
</tr>
<tr>
<td>3.5</td>
<td>10</td>
</tr>
<tr>
<td>1.27</td>
<td>8</td>
</tr>
<tr>
<td>2.10</td>
<td>7</td>
</tr>
</tbody>
</table>

**Subjects A and B**

<table>
<thead>
<tr>
<th>Subject A</th>
<th>Subject B</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of DGAs in 3 most visited drawings</td>
<td>DGAs committed to shared pictorial drawings (by page number plus total)</td>
</tr>
<tr>
<td>25</td>
<td>2 11 15 17 12 3 9 - - - -</td>
</tr>
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</table>

**Subject B**

<table>
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</thead>
<tbody>
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<td>3.3</td>
<td>8</td>
</tr>
<tr>
<td>1.6</td>
<td>7</td>
</tr>
<tr>
<td>1.11</td>
<td>6</td>
</tr>
</tbody>
</table>

**Phase 1 Study No 1**

**Date:** March 98

**Brief:** Body Temperature
Appendix IV

AGA data capture sheets

Examples of:

1. Phase One - Graphic Acts by 5 minute time band
2. Phase One - Distribution of SGAs over sketches
3. Phase Two - Graphic Acts by 5 minute time band
4. Phase Two - Distribution of SGAs over sketches
<table>
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<th>Subject A</th>
<th>Subject B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphic act type / No</td>
<td>Graphic act type / No</td>
</tr>
<tr>
<td>WGA 16</td>
<td>WGA 0</td>
</tr>
<tr>
<td>DGA 1</td>
<td>DGA 7</td>
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<tr>
<td>03-07</td>
<td>03-07</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphic act by drawing number</td>
<td>Graphic act by drawing number</td>
</tr>
<tr>
<td>08</td>
<td>08</td>
</tr>
<tr>
<td>03-07</td>
<td>03-07</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphic act type / No</td>
<td>Graphic act type / No</td>
</tr>
<tr>
<td>WGA 7</td>
<td>WGA 2</td>
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<td>13</td>
</tr>
<tr>
<td>26-24</td>
<td>26-24</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphic act by drawing number</td>
<td>Graphic act by drawing number</td>
</tr>
<tr>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td>26-24</td>
<td>26-24</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphic act type / No</td>
<td>Graphic act type / No</td>
</tr>
<tr>
<td>WGA 3</td>
<td>WGA 2</td>
</tr>
<tr>
<td>DGA 16</td>
<td>DGA 11</td>
</tr>
<tr>
<td>18</td>
<td>18</td>
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<td>26-24</td>
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<td>Graphic act by drawing number</td>
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<td>Graphic act type / No</td>
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<td>26-24</td>
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<td></td>
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<td>Graphic act by drawing number</td>
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<td>Graphic act type / No</td>
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<td>33</td>
<td>33</td>
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<td>26-24</td>
<td>26-24</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>Graphic act by drawing number</td>
<td>Graphic act by drawing number</td>
</tr>
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<td>43</td>
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<td>26-24</td>
<td>26-24</td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphic act type / No</td>
<td>Graphic act type / No</td>
</tr>
<tr>
<td>WGA 12</td>
<td>WGA 7</td>
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<td>48</td>
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<tr>
<td>26-24</td>
<td>26-24</td>
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<td></td>
<td></td>
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<tr>
<td>Graphic act by drawing number</td>
<td>Graphic act by drawing number</td>
</tr>
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<td>26-24</td>
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<table>
<thead>
<tr>
<th>Subject WGA 54</th>
<th>Subject DGAs 174</th>
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<tr>
<td>Subject DGAs 120</td>
<td>Subject WGA 11</td>
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<tr>
<td>Subject drawing time 25.05</td>
<td>Subject drawing time 26.17</td>
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</tbody>
</table>

**Shared drawings**

```
1.5 1.27 1.6 1.2 1.40
2.3 2.19 2.27 2.16 2.11 2.10 2.12
3.3 2.5
```

**TOTAL DRAWINGS PRODUCED:** 85

**NOTE:** DGA are now circled SPAS
### Drawing and Designing 97

**Data Sheet 2:**

**Drawing Graphic Acts (DGAs) distributed across drawings**

<table>
<thead>
<tr>
<th>Subject A</th>
<th>Subject B</th>
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<tbody>
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<td>1 2 2</td>
<td>2 3 2</td>
</tr>
<tr>
<td>2 3 4</td>
<td>3 5 6</td>
</tr>
<tr>
<td>4 5 6</td>
<td>6 7 8</td>
</tr>
<tr>
<td>2 3 4</td>
<td>3 5 6</td>
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</table>

**Phase 1**

**Study No:** 1

**Date:** MARCH 98

**Brief:** BODY TEMPERATURE

### Table

<table>
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<tr>
<th>drawings for DGA production</th>
<th>No of Drawings comprising 3 or less DGAs</th>
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<tr>
<td>3 5 10</td>
<td>14</td>
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<tr>
<td>1 2 7</td>
<td>55</td>
</tr>
<tr>
<td>2 4 0</td>
<td>33</td>
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</tbody>
</table>

### DGAs committed to shared pictorial drawings

(by page number plus total)

<table>
<thead>
<tr>
<th>1 2 3 4 5</th>
<th>12 13 14 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 2</td>
<td>12</td>
</tr>
<tr>
<td>12 3</td>
<td>3</td>
</tr>
</tbody>
</table>

**No of DGAs in 3 most visited drawings**

| 25 | 88 |

**NOTE:** DGAs are counted SGA
**Drawing and Designing 97**

**Phase Study No 2**

**Date 11/2/98**

**Brief CHILDREN'S FLASK**

<table>
<thead>
<tr>
<th>Subject A</th>
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<tbody>
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<td><strong>Graphic act type / No</strong></td>
<td><strong>5 min time segment</strong></td>
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<td>11:15</td>
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<td>16:20</td>
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<tr>
<td>DGA 11</td>
<td>21:25</td>
</tr>
<tr>
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<td>DGA 5</td>
<td>31:45</td>
</tr>
<tr>
<td>WGA 0</td>
<td>36:50</td>
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<tr>
<td>DGA 11</td>
<td>41:55</td>
</tr>
<tr>
<td>WGA 0</td>
<td>47:00</td>
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<tr>
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<td>52:15</td>
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**End 60:00**

**Subject WGA 1**

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**Subject DGAs 91**

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**Subject WGA 3**

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</table>

**Subject DGAs 125**

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<th>Subject drawing time 25.25</th>
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**Shared drawings 20**

**End drawings produced 50**

**NOTE: DGA S**

**Now 59**
## Drawing and Designing 97

### Data Sheet 2:

**Drawing Graphic Acts (DGAs)** distributed across drawings

### Subject A

<table>
<thead>
<tr>
<th>No of DGAs in 3 most visited drawings</th>
<th>Top 3 drawings for DGA production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.2 7</td>
</tr>
<tr>
<td></td>
<td>1.7 7</td>
</tr>
<tr>
<td></td>
<td>2.2 6</td>
</tr>
</tbody>
</table>

### Subject B

<table>
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<th>No of DGAs in 3 most visited drawings</th>
<th>Top 3 drawings for DGA production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.1 11</td>
</tr>
<tr>
<td></td>
<td>4.1 9</td>
</tr>
<tr>
<td></td>
<td>2.4 8</td>
</tr>
</tbody>
</table>

### DGAs committed to shared pictorial drawings

<table>
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<tr>
<th>DGAs committed to shared pictorial drawings (by page number plus total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>34 1 23</td>
</tr>
<tr>
<td>14 2 12</td>
</tr>
<tr>
<td>18 3 19</td>
</tr>
<tr>
<td>3 4 12</td>
</tr>
<tr>
<td>5 69 66</td>
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</table>

### Phase 2 Stud No 2

<table>
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<tr>
<th>Date</th>
<th>MARCH 98</th>
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</table>

**Brief** CHILDMORES PEPSTK

---

### Shared pictorial drawings

**No of Drawings comprising 3 or less DGAs**

<table>
<thead>
<tr>
<th>No of Drawings comprising 3 or less DGAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
</tr>
</tbody>
</table>

**Subject A**

<table>
<thead>
<tr>
<th>No of Drawings comprising 3 or less DGAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
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</tbody>
</table>

**Subject B**

**NOTE: DGAs NOW CALLED SQAS**

---
Appendix V

AGA project, Phase One and Phase Two bar charts of graphic activity

1. Phase One: Studies 1 - 6

2. Phase Two: Studies 1 - 5
PHASE ONE, STUDY 1: Bar chart showing the production of Written Graphic Acts & Sketch Graphic Acts for subject pair 1 during a one hour design task in Phase One.
PHASE ONE, STUDY 2: Bar chart showing the production of Written Graphic Acts & Sketch Graphic Acts for subject pair 2 during a one hour design task in Phase One.
PHASE ONE, STUDY 3: Bar chart showing the production of Written Graphic Acts & Sketch Graphic Acts for subject pair 3 during a one hour design task in Phase One.
PHASE ONE, STUDY 4: Bar chart showing the production of Written Graphic Acts & Sketch Graphic Acts for subject pair 4 during a one hour design task in Phase One.
PHASE ONE, STUDY 5: Bar chart showing the production of Written Graphic Acts & Sketch Graphic Acts for subject pair 5 during a one hour design task in Phase One.
PHASE ONE, STUDY 6: Bar chart showing the production of Written Graphic Acts & Sketch Graphic Acts for subject pair 6 during a one hour design task in Phase One.
PHASE TWO, STUDY 1: Bar chart showing the production of Written Graphic Acts & Sketch Graphic Acts for subject pair 1 during a one hour design task in Phase Two.
PHASE TWO, STUDY 2: Bar chart showing the production of Written Graphic Acts & Sketch Graphic Acts for subject pair 2 during a one hour design task in Phase Two.
PHASE TWO, STUDY 3: Bar chart showing the production of Written Graphic Acts & Sketch Graphic Acts for subject pair 3 during a one hour design task in Phase Two.
PHASE TWO, STUDY 4: Bar chart showing the production of Written Graphic Acts & Sketch Graphic Acts for subject pair 4 during a one hour design task in Phase Two.
PHASE TWO, STUDY 5: Bar chart showing the production of Written Graphic Acts & Sketch Graphic Acts for subject pair 5 during a one hour design task in Phase Two.
Appendix VI

AGA project, design quality assessment sheet

1. Blank design quality assessment sheet
Assessment Criteria for Proximal and Remote Design Output - Quality of the Design Proposal

Condition: Remote / Proximal
Study Number: ..........................
Design Brief: ..........................................................

1. Level of communication. (How easy is it to understand the proposal from the design pages?)

| Poor | 1 | 2 | 3 | 4 | 5 | Excellent |

2. Level of 'finish' apparent in the proposal (details of overall form, materials, construction, assembly etc).

| Poor | 1 | 2 | 3 | 4 | 5 | Excellent |

3. Level of match between the requirement as described in the design brief and the proposal as seen in the design pages.

| Poor | 1 | 2 | 3 | 4 | 5 | Excellent |

4. Level of plausibility and/or practicality in the proposal

| Poor | 1 | 2 | 3 | 4 | 5 | Excellent |

5. Level of inventiveness, creativity and/or innovation in the proposal

| Poor | 1 | 2 | 3 | 4 | 5 | Excellent |

6. Appropriateness of proposal for the subjects age, education and experience.

| Poor | 1 | 2 | 3 | 4 | 5 | Excellent |
Appendix VII

SPSS off-prints

1. Descriptives

2. Comparison of Phase One and Phase Two via the t-test

3. Comparison of Phase One and Phase Two via the Mann-Whitney test
   
   3.1 Ranks

   3.2 Significance statistics
### Descriptives

#### PHASE ONE

<table>
<thead>
<tr>
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<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
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*a. Not corrected for ties.*

*b. Grouping Variable: COND