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Capitalising on the Utility Embedded in Design and Technology Activity: An exploration of cross-curricular links
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Abstract
Despite international support for cross-curricular activity involving design and technology, science and mathematics classroom practice in secondary schools has been unable to respond positively or effectively. This paper explores the ideas of purpose and utility as drivers to enable collaboration between teachers from these subjects and suggests ways in which this collaboration might take place.

Introduction
Over the past 25 years there has been agreement that cross-curricular activities involving science, mathematics and technology are an essential component of a balanced school curriculum. For example, in 1983, an expert group which conducted a comprehensive study of secondary education in America drew this conclusion: "While we recognize the integrity of the disciplines, we also believe their current state of splendid isolation gives students a narrow and even skewed vision of both knowledge and the realities of the world." (Boyer 1983 p10). Ten years later Project 2061, also based in America, reinforced this view by stating "The basic point is that the ideas and practice of science, mathematics, and technology are so closely intertwined that we do not see how education in any one of them can be undertaken well in isolation from the others..." (American Association for the Advancement of Science 1993 pp321-322). This endorsement for cross-curricular activity is not confined to America. In Israel technology education curricula in Israeli junior high schools (grades 7-9) were combined into one mandatory subject: 'Science and Technology'. In addition, a new 'Science and Technology' national curriculum was developed, with collaboration between science and technology education as a central ideal: "...Collaboration between science and technology is essential because of the growing linkage between scientific subjects and relevant technologies and also because of the unclear borders between them." (Israeli National Curriculum for Science and Technology, 1996 p5). In England the specialist Engineering Colleges, catering for students aged 11-19 years, have the following as part of their vision statement:

Through a focus on enhancing understanding of the relationship between design & technology, mathematics and science, underpinning a broad curriculum, engineering colleges will raise standards of achievement for all students across the ability and subject range, leading to whole school improvement by providing increased diversity through opportunities for students to follow a wide range of vocational pathways.

(Barlex, 2005 p12)

David Hargreaves (2000) in his speech 'Towards Education for Innovation' noted the cross curricular experience required for creativity and innovation, "Allowing different sorts of knowledge, disciplines and expertise to collide produces the spark of a new idea and what's needed to turn it into an innovation." And he was particularly supportive of the role of design and technology in providing this experience.

In the school curriculum, design & technology has a notable place in this regard, as a domain in which different bodies of knowledge and skill come together. Design & technology is not only a bridge linking the arts to science and mathematics in the interest of curriculum coherence; it is also a highly fertile ground for activities that support innovation. ... Design & technology is moving from the periphery of the school curriculum to its heart, as a model of the combination of knowledge and skills that will be at a premium in the knowledge economy, and it is from the best practice that other subjects can learn about effective teaching and learning for innovativeness.

(Hargreaves, 2000 pp6 & 7)

The most recent revision of the programme of study for design and technology in England includes following the statement promoting the use of cross-curricular links.

In ways appropriate to the product area, the curriculum should provide opportunities for pupils to:
• make links between design and technology and other subjects and areas of the curriculum. This includes using knowledge from other subjects and from outside the school in designing and making or using design and technology to give context and meaning to the application of other programmes of study.

(Qualifications and Curriculum Authority 2007).
However, despite the support for cross curricular activity and the explicit acknowledgement that the nature of design and technology lends itself to such activity, the reality of practice in secondary schools paints a different picture. The Interaction Report (Barlex and Pitt 2000) noted that “In schools a separate and almost unrelated relationship exists between science and design & technology in direct contrast to that between science and technology in the world outside school.” (p5) The report found that “Each group [science and design and technology teachers] holds coherent views about its own subject, but a variety of views about the other subject few of which coincide with the view from inside that other group.” (p24) The report ‘Becoming an Engineering College’ (Barlex 2005) explored the collaboration that was taking place in schools with the specific brief to develop cross curricular links. Teachers cited the prescriptive nature of the National Curriculum in mathematics and science as a barrier to developing links with design and technology. The lack of quality time to develop and plan collaborative activities was also cited as a reason for a lack of cross-curricular work. The nature of some of the difficulties encountered when science and design and technology teachers attempt to collaborate has been revealed through a case study approach (Lewis, Barlex and Chapman 2007). This research showed that the misaligned views of the subjects collaborating led to a situation where the teachers challenged each others’ subject knowledge and pedagogical culture. For example whilst food technology teachers were content to discuss the nutritional value of food stuffs at the macro level of sugars and starches the science teachers insisted that it was necessary to look at the behaviour of foods in digestion at the molecular level. Whilst these two approaches could have been seen as complimentary and building a more complete picture in this situation the difference of approach led to professional antagonism. Similarly within electronics whilst the design and technology teachers argued that pupils only needed to understand functional characteristics of components to be successful in simple circuit design the science teachers thought it necessary for pupils to understand why a component behaved as it did. Again these positions can be seen as complimentary and potentially mutually reinforcing but here these different positions led to disagreement over learning outcomes. Underlying both sets of disagreements are misunderstandings of the nature and purpose of knowledge within the two curriculum areas. Science is primarily concerned with exploration and explanation of what exists developing and using declarative knowledge whereas design and technology is concerned with the conception of what does not yet exist and how it might be brought into existence requiring and developing normative knowledge (de Vries 2005).

So a key question is: “What might act as a driver for collaboration?” And it is essential that the driver has appeal to the different constituencies engaged in the collaboration.

Ainley, Pratt and Hansen (2006) address this question by considering a planning paradox. If teachers plan from tightly focused learning objectives, the tasks they set are likely to be unrewarding for pupils and [in the cases they are considering] mathematically impoverished. If teaching is planned around engaging tasks the pupils’ activity may be far richer, but it is less likely to be focused and learning may be difficult to assess. They suggest that the two constructs of purpose and utility offer a framework for task design that may resolve the planning paradox. Designing tasks that are purposeful for learners ensures that the activity will be rich and motivating. Such purposeful tasks provide opportunities to learn about the utility of particular ideas. They quote as an example of a task that has both purpose and utility designing a spinner that will stay in the air as long as possible. Taking the length of the wings as a key variable, pupils can experiment with spinners of different wing dimension and record results in a spreadsheet. They report that initially pupils had difficulty in seeing patterns in the numerical data but by using a scatter graph to display the results pupils were able to identify patterns, make conjectures about the effects of changing wing length and identify further areas for investigation. From a designerly point of view there will be factors other than time in the air to consider in developing such a spinner as a play thing – an appearance that has user appeal, from a material that does not easily break, is relatively straight forward to manufacture, and can, perhaps be incorporated into others toys such as a spinning ‘parachute’ for a small action figure. But the preliminary modelling and investigation of spinner behaviour using the idea of fair testing from science (appealing to the science teacher) and a scatter graph to reveal patterns in the results (appealing to both the science and the mathematics teacher) would surely enhance the overall design activity (appealing to the design and technology teacher). Some teachers might view limiting pupils to designing spinning ‘flyers’ as the basis for a toy as too restricting and prefer a more open brief concerning ‘toys that fly’. But even in this more open situation it will be possible to use science and mathematics to enhance pupils’ investigations of ‘in flight’ performance.

**Exploration**

Barlex, (2004) has suggested that in the context of school-based designing, pupils’ designing could be described in terms of making five types of interrelated design decisions: (a) conceptual (b) marketing (c) technical (d) aesthetic and (e) constructional. Conceptual decisions are concerned with the
overall purpose of the design, that is, what sort of product it will be. Marketing decisions are concerned with, for example, who the design is for, where will it be used and where will it be sold. Technical decisions are concerned with how the design will work. Aesthetic decisions are concerned with what the design will look like. Constructional decisions are concerned with how the design will be put together.

This can be represented visually, as shown in Figure 1, with each type of decision at a corner of a pentagon and each corner connected to every other corner.

This inter-connectedness is an important feature of making design decisions. A change of decision within one area will affect some if not all of the design decisions made within the other areas. Barlex and Trebell (2007) have used this categorisation of design decisions as a effective tool to probe the nature and extent of design decisions made by pupils designing, but not making, products for the future. Barlex (2007) has reported that the design decision pentagon can be extended by asking three very important supplementary questions concerning the impact of the product resulting from the design decisions:

- What is the social impact?
- What is the economic impact?
- What is the environmental impact?

A strategy for developing a cross-curricular approach to pupils designing is the use of design decision analysis to identify links with other subjects. At a general level this is a straightforward exercise. It is likely that technical design decisions will be informed by scientific knowledge and understanding and that in pursuing these mathematical knowledge and understanding might be required. Aesthetic design decisions will be informed by learning in art and design. Marketing decisions that require pupils to find out about user preferences may well require the use of mathematics and ICT. Constructional decisions will require the use of mathematics, not simply in accurate measurement, although this is important, but in using geometry to appreciate the spatial relationship between the component parts. If the scope of the exercise is widened to include the supplementary questions then the links to other subjects proliferate. Social impact considerations immediately involve PSHE (personal, social and health education) and citizenship and may also involve history. Economic impact will involve business and economics. Environmental impact will involve geography as well as science.

The problem with this proliferation of possible links is that resulting curriculum is so complex that it becomes impossible to manage and the significance of any one link within the matrix is so small as to be trivial. There needs to be a way to decide which links to embrace and enhance and which links to forgo. And it is here that the ideas of purpose and utility may prove particularly useful.

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**Figure 1:** The design decision pentagon
Discussion

There can be little doubt that genuine designing and making assignments are by their very nature purposeful. Through the act of designing the designer conceives that which does not yet exist. This is in response to a need or opportunity and the intention is that the resulting product, system or environment will lead to an improvement of some sort. The items designed and made by pupils will of course vary in complexity. For younger pupils they will of necessity be on a very modest scale: a pop up card to cheer up a sick relative for example. As pupils become older and more adept at designing and making they can respond to more demanding challenges: a lightweight trailer to aid the transport a canoe over rough ground for example. The issue is not the purpose of design tasks but the utility of other subject contributions in helping the pupil make better design decisions so that through the cross curricular engagement the learning and the final product are an improvement on what would have been produced in the absence of this engagement. It is of course essential to avoid tokenism in two aspects of this endeavour. The designing and making assignment must be such that pupils have the power to make design decisions. The contribution of the other subject or subjects must be significant rendering its utility apparent to the pupils. In the two examples cited above, although they are operating at very different levels of conceptual demand, there are opportunities to use ideas from science (appreciating that materials have properties, the nature of these properties and that some properties are more relevant to particular performance than others) and mathematics (the locus of moving parts in simple mechanisms).

To achieve this purpose and utility it will be necessary for design and technology teachers to expose in some detail the nature of the designing and making assignment they wish their pupils to tackle. The detail that will come under scrutiny in two parts. First the nature of the design decisions that the pupils are being asked to make must be scrutinised to ensure that these are significant as it is this decision making that will give the task its purpose. Second this analysis of design decisions must be shared openly with colleagues from other subjects so that they can make suggestions as to elements from their subjects that might provide utility. Developing the designing and making task so that its purpose and other subject utility are revealed and enhanced is not a trivial task. Hargreaves (1998) has considered this sort of activity as generating new professional knowledge. He argues that it is insufficient for schools to provide the opportunity for teachers to generate ideas (in this case about designing and making assignments that have both purpose and utility) but that in addition it is essential that there is support for this process as good ideas, especially when they come from new or more junior members of staff, are fragile and may need protection. An atmosphere of cynicism will kill knowledge creation.

What mechanisms are available to facilitate the development of the new professional knowledge required to devise designing and making assignments with purpose and utility. Engestrom (2004) has developed the idea of knot working. This involves solving urgent tasks where the combinations of people and the contents of the tasks are likely to change. The members of the group convened to tackle the problem are chosen on the basis of the experience in relation to the nature of the problem. In the case under consideration here such a group might consist of two design and technology teachers, a science teacher and a maths teacher. In such a group it will be important to put aside issues of status and position and concentrate on the task in hand, with each person making a contribution according to their relevant expertise. This may be an unusual activity, but the potential for curriculum development that enhances cross-curricular activity is high.

John-Steiner (2000) has written at length about the issues facing those who wish to work across and within disciplines. She argues that it will require different sorts of partnership but they will all thrive on dialogue, risk-taking and a shared vision. Such successful collaboration always involves trust and this has to be earned by those working together. Without trust it is not possible to reveal and overcome the insecurities and uncertainties that underpin all creative endeavours. Working with colleagues in this way requires those involved take the bold step of becoming dependent on one another. This dependence is not a sign of weakness, but of strength; a dignified interdependence through which those working together have mutual respect and can forge achievements far beyond their individual, isolated capacities. Design and technology teachers working with colleagues from other subjects in an endeavour to develop powerful designing and making assignments with both purpose and utility typifies the sort of collaboration that John Steiner has described. It is both professionally rewarding and personally exhilarating. The current revision of the Key Stage 3 curriculum initiated by the Qualifications and Curriculum Authority holds the promise that the cross-curricular activity described here will become the norm rather the exception.

Possible next steps

Many local authorities in England employ advanced skills teachers (ASTs) to provide professional support and guidance for other teachers. Collaboration between ASTs from design and technology, science and mathematics developing designing and making assignments with purpose and utility would be an interesting and useful exercise. The Design and
Technology Association in collaboration with the Audi Design Foundation has just inaugurated a New Talent Scheme through which a group of talented young teachers will be mentored in the early stages of their career. Exploring the place of design and technology in a cross-curricular setting with special reference to purpose and utility would be a challenging and exciting task for this group.

Response to the recent Science, Technology, Engineering and Mathematics (STEM) Programme Report (Department for Education and Skills 2006) by the professional teaching associations – Association for Science Education, Design and Technology Association, Association of Teachers of Mathematics – could use the ideas of purpose and utility in pedagogic tasks as a powerful indicator of the willingness to support the collaboration necessary for cross-curricular developments.

In all the activities suggested above it will be important for those involved to put their ideas into practice and work closely with the educational research community in evaluating their effectiveness, identifying strengths and weaknesses and developing models of transferable good practice.

Summary
The paper has described some of the support for cross-curricular activity involving science, mathematics and technology that has developed in recent years in different countries but notes the difficulties experienced in England in achieving success for these activities in the secondary school classroom. The paper has identified the use of purpose and utility as key concepts that might act as a driver for collaboration in cross-curricular activity and explored the use of a design decision analysis tool as a means of ensuring purpose and identifying the potential for utility. The paper has discussed how considering purpose and utility in designing and making assignments can be viewed as generating new professional and suggested how this might be achieved. Finally the paper makes specific suggestions for the next steps to be taken to develop cross-curricular activity in involving design and technology, science and mathematics.

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References


