Assessing Capability in Design and Technology: The case for a minimally invasive approach

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Abstract

The approach to assessing capability in design and technology advocated requires four features. First, there is the requirement for tasks that are culturally and personally authentic through which pupils can demonstrate designerly behaviour by making design decisions. Second, there is the requirement that the pupils use job bags, whose contents are based on utility, as the means of making and recording their design decisions. Third there is the requirement that scripted probes are used at key points in the design task to enable pupils to divulge and record their designerly thinking through revealing and justifying their design decisions. Fourth, it requires teachers to play the part of mentor and client in helping pupils use the scripted probes effectively.

The paper is in seven parts. Part 1 briefly explores the difficulties in defining designerly activity. Part 2 considers some of the problems in revealing designerly activity. Part 3 considers the nature of tasks that might be appropriate for assessment in design and technology. Part 4 considers how designing might be describes as a set of interrelated design decisions. Part 5 describes how such design decisions might be revealed and justified through the use of a series of scripted probes. Part 6 considers the nature of the portfolio that enables pupils to make design decisions. In the conclusion, the paper summarises the approach to assessment developed so far and justifies it in terms of overcoming the problems of revealing designerly activity and having minimum impact on the pupils experience of designing.

While most of the examples in this paper are drawn from the specific context of assessment in England and Wales, the ideas and issues raised and discussed will have relevance for all concerned with developing authentic approaches to assessment in Technology Education.

Key words

assessment, design & technology, designerly behaviour, design decisions

Introduction

Richard Kimbell (2004) sums up the situation with regard to current assessment practice in design and technology as "widely regarded as having become formulaic, routinised and predictable". He takes this criticism further stating that "it has become increasingly evident over the last few years that a number of pressures have combined to reduce learners' innovative performance at GCSE in design and technology. 'Playing safe' with highly teacher managed projects has been seen to be the formula for schools guaranteed A-C pass rate". (Kimbell 2006)

In response to the concerns he raises there has been renewed interest in assessment and this has led to the *Assessing Design Innovation* research project, which has produced structured testing materials to be used over two half day blocks under examination conditions. This is a huge step forward compared to the stranglehold that the coursework portfolio has over pupil assessment in design and technology. Despite the undoubted achievement of this research project I have reservations about a one-size fits all timed test as the best way for pupils to reveal their capability. In this paper I explore a related yet significantly different alternative.

Defining designerly activity

Designing is a complex activity. Brian Lawson (2004) makes an intriguing analogy with playing chess:

> Designing then, in terms of chess, is rather like playing with a board that has no divisions into cells, has pieces that can be invented and redefined as the game proceeds and rules that change their effects as moves are made. Even the object of the game is not defined at the outset and may change as the game wears on. Put like this it seems a ridiculous enterprise to contemplate the design process at all! (p.20)

Ridiculous enterprise or not it is important to try as designerly activity lies at the heart of the school subject design and technology.

Nigel Cross (2000) clarifies the situation by describing how designing is an iterative process that is heuristic

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rather than algorithmic, one that uses "previous experience, general guidelines and rules of thumb that lead in what the designer hopes to be the right direction, but with no absolute guarantee of success" (p.29).
Moving forward in what the designer hopes is the right direction requires building the knowledge necessary to develop a solution to the design task. In designing for a client in a commercial environment the designer has to acquire knowledge from a wide variety of sources – the client, potential users of the designed item, legislators, regulators and makers (Goel, 1995). This suggests that the vast majority of the knowledge used to solve the design problem is brought into the process by the designer.

Lawson (2004) takes this idea a stage further by considering the process of design as knowledge transformation, in which knowledge provided by clients (knowledge about problems, needs and requirements) is used by the designer (who has knowledge about solution forms and possibilities) and transformed into knowledge of the solution. This indicates that whilst knowledge is important in any assessment of designerly activity the exact nature of that knowledge is not certain, since it is assembled by the designer in response to the task, much more important is what the designer does with that knowledge in developing a solution. Hence any assessment of pupils engaged in designerly activity should focus heavily on process. Lawson (2004) also points to the importance of the design brief throughout the design process.

> Thus the idea that briefing is an early stage in the design process that consists of a one-way flow of information from client to designer, although persistent, is extremely misleading. In fact briefing is an integral part of designing and is more sensibly seen as a continuous and highly interactive way of eliciting knowledge. (p.29)

This is in complete contrast to the way that Examination Awarding Body course work marking schemes treat the design brief. For example the current EdExcel and AQA specifications make little mention of design briefs.

Uncovering designerly activity
If the pupil is to be assessed as a designer it is necessary to have ways of revealing the thought processes that inform designerly activity. Bryan Lawson (2004) cites four methods for finding out how designers are thinking: (a) considering the information designers are given and the information they produce, (b) observing the designer operating under a controlled situation, (c) observing the designer operating in the 'natural' surroundings of their studios, and (d) asking designers about what they do gaining responses in either writing or by means of interview. He notes the advantages and disadvantages of each. Simply considering input and output of information may encourage speculation as to how the designer has been thinking but provides no concrete evidence.

Observing the designer in controlled situations has the drawback that it is extremely difficult to conduct with sufficient degree of realism to be relevant to what a designer might actually do in practice. Observing the designer operating in 'natural' surroundings offers realism but much of significance may stay hidden. Questioning designers about what they do is problematic. They may with the benefit of hindsight present a more logical and coherent account of their thinking than that which actually took place. If in assessing the pupil as designer we attempt to reveal their designerly thinking it is important that we are aware of the limitations revealed by Lawson's analysis.

Setting appropriate tasks
An essential pre-requisite to any assessment of designerly activiy is that the tasks used for the assessment are as similar to professional design activity as possible. Patricia Murphy and Sarah Hennessy (2001) refer to such tasks as "authentic tasks" and have identified two interrelated but distinct aspects – personal authenticity and cultural authenticity. A design activity that has *personal authenticity* requires the pupil to identify a need and is orientated towards clients and markets that he or she can relate to. Pupils will be involved in the context of the problem (e.g. providing purposeful activities for young children during rainy playtimes at school). This leads the activity to have personal meaning and relevance for the pupil. The activity should require the pupil to make significant decisions:

decisions that allow him or her to be designerly (e.g. identify the user, specify the product, propose a solution; not simply make relatively trivial decisions about colour or aesthetic elements of the shape). Being in control and having autonomy, including making a range of design decisions, are all part of what creates personal authenticity in the activity.

Culturally authentic design activities relate to activity in the world outside school – in this case in the community of practice of designers. This implies clarifying who the pupil is in the process, e.g. a designer within a company specialising in particular sorts of product, a member of a design team with a particular responsibility (if the design activity is collaborative). In the school situation, this might be extended to the pupil acting as a manufacturer to the extent that he or she might be required to produce a fully working, usable prototype. It is also important to clarify the relationship to any client, e.g. the elder sibling of a young child or friend of a teaching assistant who has to supervise rainy day play times. Culturally authentic design activities are sophisticated and "real" e.g. design a series of interactive 2D and 3D jigsaw puzzles that could be used to amuse young children during rainy day play times.

Within design and technology it is important that the design activities undertaken by pupils are as far as possible, both personally and culturally authentic if they are to provoke a genuine as opposed to tokenistic response from pupils. This is true for activities that are used for assessment for learning and assessment of learning.

Designing through making design decisions

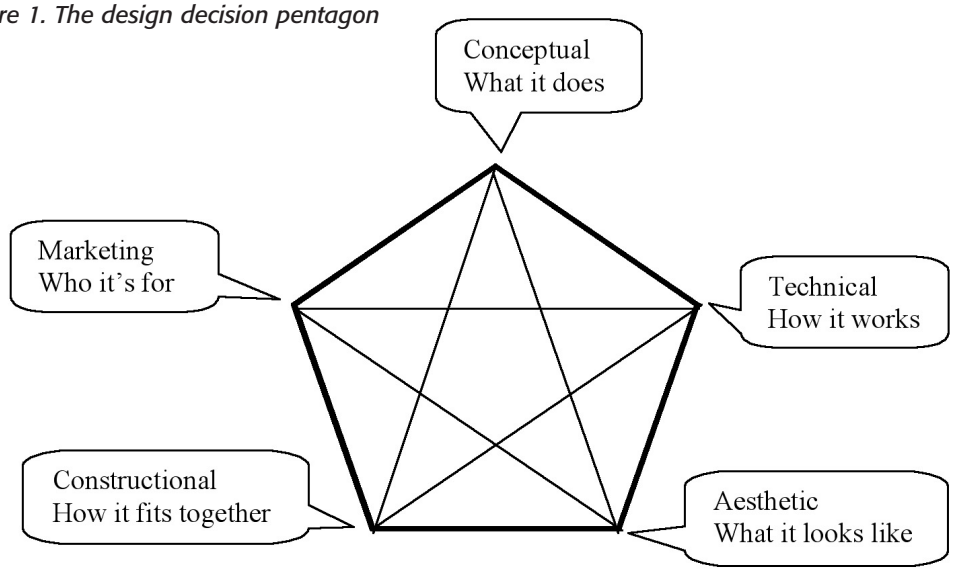
In moving the design activity from the arena of the professional into the classroom, it is important to develop a description of the activity that is useful for teaching, learning and assessment. This process begins by identifying suitable descriptions of the professional activity. According to Buchanan (1996), designers are challenged to conceive and plan what does not yet exist.. Ropohl (1997) has further described this activity as requiring:

> [The development and design of] a novel technical system, anticipat[ing] the object to be realised through mental imagination. [The designer] has to conceive of a concrete object which does not yet exist, and he [***sic***] has to determine spatial and temporal details which cannot yet be observed, but will have to be created by the designing and manufacturing process. (p.69)

"Conceiving what does not exist" (Buchanan, 1996) and "developing and designing a novel… system" (Ropohl, 1997) indicate that pupils will, on occasion, be required to make conceptual design decisions. "Developing and designing a… technical system" (Ropohl) indicates that pupils will need to make decisions about the way their design will work, that is, make technical design decisions. "Spatial and temporal details which cannot yet be observed" (Ropohl) indicates that pupils will need to make decisions about the appearance of their designs, that is, aesthetic decisions. Finally, "created by the… manufacturing process" (Ropohl) indicates that students will need to consider how they will make their design, that is, constructional decisions. Rophol does not explicitly consider the user yet product designers have commented on how important it is to consider the user when developing design proposals. For example, Jonathan Ive, the designer of the iPod states, "the design of an object defines its meaning and ultimate utility. The nature of the connection between technology and people is determined by the designer" (Department for Education and Employment, 1999, p. 14). This indicates that some of the decisions made by pupils should be informed by a consideration of the user. As these considerations will be broader than any one group of users, such considerations are perhaps better described as market considerations. This indicates that pupils will need to make decisions related to the market for their product.

Decisions in these five domains (conceptual, technical, aesthetic, constructional and marketing) are not made independently of one another, for as Buchanan (1996) states: "a designer must attend simultaneously to many levels of detail and make numerous decisions as he or she designs." Hence, Barlex (2004) has suggested that these areas of design decision can be represented visually, with each type of design decision at a corner of a pentagon and each corner connected to every other corner. This is shown in Figure 1.

Figure 1. The design decision pentagon



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 others. For example, a change in the way a design is to work will almost certainly affect what the design looks like and how it is constructed. It may also have far-reaching effects in changing some of the purposes that the design can meet and who might be able to use it. One can envisage a student making a series of "What if I did this" moves (Schön, 1987) as he or she considers possible decisions about a feature and its effects on decisions made or yet-to-be-made about other features. This inter-connectedness reflects a constructivist reflection-in-action paradigm for the student considering the process of designing as a reflective conversation with the situation (Dorst & Dijkhuis, 1995). Yet the utilization of a "What if I did this" strategy is more than a mere *ad hoc* tool to cope with the complexity of designing. Its repeated use increases the designer's understanding of the issues, thereby informing, guiding and stimulating further designing both within and outside of the given design situation (Schön & Wiggins, 1992). It is, in effect, a powerful learning tool that the designer uses to learn about the design proposal as he or she is creating it (Sim & Duffy, 2004).

The model of designing as a series of interrelated design decisions at different levels of detail culminating in a design proposal that is realised through making is useful for teaching, learning and assessment. The teacher can use the model to focus a pupil's attention on what it means to design. The model allows the pupil to focus deliberately but not exclusively on particular features of his or her designing. The model allows the assessor to focus on particular features of a pupil's designing without losing the important holistic overview of the design process.

Revealing designerly thinking in fledgling designers

Dorst (2003) has identified five levels of expertise novice, beginner, competent, proficient and expert. Trebell (2007) has suggested that pupils studying design and technology be considered as fledglings to provide a category specifically for pupils who will be designing without having had to show prior aptitude and proficiency in the field. It is important that any task to be used for assessing fledgling's designerly thinking should be both personally and culturally authentic and be scrutinised in terms of the design decisions the pupil makes in tackling the task. So the next requirement is to develop a device that enables the pupil to reveal and justify his or her design

decisions. For the moment I will put on hold the means by which the pupils makes the design decisions. I am concerned with revelation (making the design decisions apparent) and justification (substantiating the design decisions). What is required is the means to allow pupils to reflect on and reveal their progress in making design decisions as the task progresses. Essentially the assessment exercise has to probe and record chronologically the pupil's thinking. Such probing must take place as a pupil moves through the design task. I suggest that probes are required at three junctures in any design and make activity.

The first probe will be used when a pupil has developed his or her first ideas for a product. A pupil will be asked to consider whether his or her proposals meet the requirements of the brief and to clarify and justify the design decisions made so far. The pupil will also be required to review these decisions and consider whether what he or she is proposing is likely to be achievable in relation to resources of time, materials, equipment and personal skills.

The second probe will be used when most of a pupil's design decisions have been made through sketching, 3D modelling, and experimenting. This will be at the point where making is imminent or has just started. Again, the pupil will be asked to clarify and justify the design decisions made so far. Again, the pupil will also be required to review these decisions and consider whether his or her design fully meets the requirements of the brief and whether his or her plans for making are achievable.

The third probe will be used when the product is complete and will include an evaluation against the brief and the specification.

These probes will be used by pupils working in pairs or small groups under structured guidance with their work on the design task available for reference. The probes will provide a script through which pupils can reflect on and justify their design decisions. Using the support provided by the guidance in the probes, they will record their discussions about the effectiveness of their work at each stage and will be able to refer to their teacher for guidance. The role of the teacher is important as he or she can, to some extent, take the role of the client and provide the on going briefing that is seen by Lawson (2004) as "an integral part of designing" (p.29). The teacher contribution to the probe can also be part of the script.

The emphasis of the probes will be on revealing a pupil's response to the emerging demands of the task in terms of the design decisions made and the extent to which they are realistic.

It is my expectation that the information provided by the probes will be of such value to teachers and pupils that they will be used throughout a course of study in design and technology as a part of assessment for learning in the normal curriculum, rather than only with specific tasks used for assessment of learning. Such use would develop pupil familiarity with the probes.

The coursework portfolio – a new lease of life?

In recent years Mike Ive (ex HMI subject adviser for design and technology) repeatedly used the term "neat nonsense" to describe the undue time and effort given by many pupils (and teachers) to the presentation of design folios at the expense of content. Jon Parker, (2003) echoed this when he gave his personal perspective on the issues based on his experience as both an Office for Standards in Education Inspector and a Local Education Authority advisor:

> To a large extent, the tail wags the dog. Teachers are reluctant to change their practices when they have established strategies to ensure their A* to C grades each year. GCSE coursework assessment procedures discourage teachers from breaking the mould. They seem more typically to reward those students who can jump through the assessment hoops rather than encouraging those who are able to show real flare and imagination. The development of creativity in students, the opportunity for them to propose imaginative solutions, take risks, be intuitive, inventive, and innovative in their work, has been sidelined by an approach which has become far too mechanistic. (p.7)

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Nick Givens (1998) clarifies the problem:

> Our [the teacher's] problem always has been, and remains, that of finding efficient painless ways of generating EVIDENCE that don't stifle the creativity. So the ritualisation of designing, the conversion of the design folio into a product and the inflexible narrow interpretation of what constitutes design, represent a major problem. There needs to be scope for pupils to model and record their thinking in a variety of ways AND orders. We can't carry on letting a narrow view of what constitutes EVIDENCE-of-design dictate the nature of design.

Interestingly, professional designers make a clear distinction between the portfolio they use to promote their work and the means by which they make and record their design decisions (Welch & Barlex, 2004). They avoid the trap of neat nonsense. Whatever they do is useful in developing their design ideas and they keep an on-going record of their design decisions as they are made in an artefact sometimes called a "job bag". I propose that pupils should keep job bags. The criteria for the contents are simple. Their work, be it in the form of written notes, annotated sketches, 3D models, working drawings, patterns, recipes, plans, schedules, still photos, video recordings, audio recordings, questionnaire data, calculations, must have utility. It must be present only because at the time it was produced it was done to help make a design decision. Such a miscellany would be personal to the pupil and it is likely that there would be considerable variation in content of such job bags amongst pupils tackling identical design tasks. However, the job bag would not be the primary source of assessment evidence. It would be the evidence that the pupil called upon to reveal and justify their design decisions. And it is the revelation and justification of the design decisions demonstrated at three points during a design task via the probes described above that provides the bulk of the assessment evidence for the pupil's designerly activity. The artefact produced, seen in the context of the design decisions that were responsible for its genesis, is now a more useful item for assessment purposes and is the focus of the third probe.

The job bag can have various manifestations. Nick Givens writing in the Nuffield Teacher Guide (Barlex, 2000) sees the basis of the job bag as an exercise book, somewhere between A5 and A4 in size with a hard cover and alternative blank and lined paper. "The key thing is", he says, "that the pages stay in the right order and nothing can get lost. You've got a complete record" (p.27). Jon Parker, also writing in the Nuffield Teacher Guide takes a different view. "It should be like a largish Filofax, with all sorts of different paper – plain, lined, coloured, graph. It's possible to stick all sorts of samples either directly onto a page or in a plastic pocket" (p.27). Dave Hayles, working at Saltash Community School, Cornwall, England, takes a more radical approach. For pupils in Key Stage 3 he lays out three roles of lining paper across the benches of a workshop. Each pupil is given a space on the lining paper and records his or her designerly thinking and emerging design decisions on that space. The design decisions of every pupil in the class are on show at all times. They can see each other's work, thus allowing them to gain ideas from each other. This approach mirrors that of some professional designers who work in a way which enables them to keep the story of their design in view at all times (Lawson, 2004). The key point here is that the teacher can help pupils develop job bags that are appropriate for the way they choose to design rather than follow an Examinination Awarding Body prescription.

There are interesting opportunities to explore different ways of using time in this job bag/probe assessment model. It will work in the traditional two double periods a week across one or two terms. It will also work in situations where time is organised to provide pupils with a more immersive experience of designing. These can be a sequence of half-day blocks or whole-day blocks. In response to the Excellence and Enjoyment publication (Department for Education and Skills 2004) many primary schools are now using termly two or three-day blocks as the means of teaching design and technology. Whilst it is easier for primary schools than secondary schools to organise block time, there is a strong argument for all schools to be more flexible in the way they use time. In terms of cultural authenticity, an immersive experience of designing is much more like that experienced by a professional designer than the disjointed approach afforded by the traditional school timetable.

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Conclusion

The approach to assessing capability in design and technology that I am advocating requires four features each of which will require significant research and development. First, there is the requirement for tasks that are culturally and personally authentic through which pupils can demonstrate designerly behaviour by making design decisions. A range of potential tasks are available e.g. the Nuffield Design & Technology Capability Tasks available at www.secondarydandt.org but it will be important to investigate their suitability for this purpose and modify as necessary. Second, there is the requirement that the pupils use job bags, whose contents are based on utility, as the means of making and recording their design decisions. The job bag will be a new concept for many teachers, and is very different from the highly structured, linear portfolio currently required for GCSE coursework assessment. Teachers will need significant professional development to become confident and competent in supporting pupils in the use of job bags which reflect diversity in pupil approaches to designing. Third there is the requirement that scripted probes are used at key points in the design task to enable pupils to divulge and record their designerly thinking through revealing and justifying their design decisions. This is a particularly challenging aspect of the development and a variety of approaches to scripted probes will need to be piloted and evaluated. Fourth, it requires teachers to play the part of mentor and client in helping pupils use the scripted probes effectively. As with managing job bags, teachers will need professional development to be successful here. With this successful development the suggested approach will go some way to meeting Lawson's (2004) reservations about ways to capture design thinking. The fledgling designer can be placed in as natural a situation as possible, the use of the scripted probes does not unduly interrupt or distort the design activity. In fact it can be seen to enhance designerly thinking. It is not subject to retrospective justification.

And the approach has the considerable advantage that it can be used as an integral way of teaching and learning as well as assessment so that its use as an assessment device becomes almost invisible. As such its ability to distort the educative experience is minimised. An ideal view of the impact of assessment is given, by analogy, in this quotation:

> *Casterbridge was the complement of the rural life around, not its urban opposite. Bees and butterflies in the cornfields at the top of the town, who desired to get to the meads at the bottom, took no circuitous course, but flew straight down High Street without any apparent consciousness that they were travelling strange latitudes.*
>
> p.55 Chapter 9 The Mayor of Casterbridge by Thomas Hardy

If we consider the pupil as the bee or butterfly, their learning as their experiences in a journey across the countryside, then any assessment procedures should have as little impact on the pupil as Casterbridge did on the bee or butterfly.

This may be an idealistic view but the approach outlined here, I believe, goes a considerable way to meeting that ideal.

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References

Barlex, D. (2004) Creativity in School Technology Education: A Chorus of Voices. In Howard Middleton, Margarita Pavlova & Dick Roebuck (Eds.), *Learning for Innovation in Technology Education* 24-37. Brisbane, Australia, Centre for Learning Research, Griffith University

Barlex, D. (2000) *Nuffield Design & Technology 11-14 Teacher's Handbook*, Harlow, Essex, Longman

Buchanan, R. (1996). Wicked problems in design thinking. In V. Margolin & R. Buchanan (Eds.), *The idea of design* 3-20. Cambridge, MA: MIT.

Cross, N. (2000). *Engineering design methods: Strategies for product design* (3rd ed.). Chichester, UK: John Wiley & Sons.

Department for Education and Employment (1999). *Design and technology The National Curriculum for England,* London: Department For Education and Employment

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Department for Education and Skills (2004) *Excellence and Enjoyment : learning and teaching in the primary years. Learning to learn: key aspects of learning across the primary curriculum,* London, UK HMSO

Dorst, K. (2003) The problem of design problems. In *Expertise in Design.* N. Cross and E. Edmonds. Sydney, Creativity and Cognition Studios Press

Dorst, K., & Dijkhuis. J. (1995). Comparing paradigms for describing design activity. *Design Studies,* 16, 261-274.

Givens N. (1998) in *Nuffield D&T Project response* to the National Advisory Committee on Creative and Cultural Education

Goel, V (1995) *Sketches of Thought*. Cambridge, Mass., MIT Press

Hardy, T. (1987) *The Mayor of Casterbridge*, Oxford, Oxford University Press

Kimbell, R (2006) 'Innovative Performance and Virtual Portfolios – a tale of two projects' *Design and Technology Education; An International Journal,* Wellesbourne: Design and Technology Association, Vol. 11 (1), 18-30

Kimbell, R., (2004) 'Assessment in Design and Technology Education for the Department of Education and Skills' in *Learning for Innovation in Technology Education Conference*, Brisbane Australia: Griffith University, Vol. Two, 99-112

Lawson. B. (2004), *What designers know,* Oxford, UK, Elsevier

Murphy, P., & Hennessey, S. (2001). 'Realising the potential – and lost opportunities – for peer collaboration in a D&T setting.' *International Journal of Technology and Design Education,* 11, 203-237.

Parker, J. (2003). 'Weaknesses revealed.' In D. Barlex (Ed.), *Creativity in crisis? Design & technology in KS3 and KS4* 6-8. London: Nuffield Foundation.

Rohpol, G (1997) 'Knowledge types in technology,' *International Journal of technology and Design Education,* 7, 65-72.

Schön, D. A. (1987). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions.* San Francisco: Jossey-Bass.

Schön, D. A., & Wiggins, G. (1992). 'Kinds of seeing and their functions in designing.' *Design Studies*, 13, 135-156.

Sim, S. K., & Duffy, A. H. B. (2004). 'Evolving a model of design learning.' *Research in Engineering Design*, 15, 40-61.

Trebell, D (2007) 'A Study of Designerly Activity in Secondary Design and Technology – A Literature Review in Search of an Appropriate Theoretical Perspective to justify my approach to analysing data submitted to IDATA Conference' submitted to *the Design and Technology Association International Research Conference 2007*

Welch, M and Barlex, D. (2004) 'Portfolios in design & technology education: Investigating differing views' In E. W. L. Normans, D. Spendlove, P. Grover & A. Mitchell (Eds.), *DATA International Research Conference 2004*, 193-197, Sheffield, UK, Sheffield Hallam University.