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Key factors which affect pupils performance in technology project work

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Abstract

This paper reports the findings of a study into the perceptions of pupils and teachers regarding factors affecting performance in technology project work. The research was carried out in eight case study schools selected from an initial survey of fifty schools in seven Local Education Authorities in the North East of England. It involved interviews with forty Year 11 pupils and eight Design and Realisation teachers from the Case Study Schools.

The study forms part of an ongoing research project concerned with identifying the causes of de-motivation amongst pupils in Years 10 and 11 following courses in technology.

Using the analysis of the data collected from the interviews, the paper will discuss the key factors which pupils and teachers perceive to affect performance in technology project work.

This paper reports the findings of a study into the perceptions of Key Stage 4 pupils and their teachers regarding factors affecting performance in Technology [1] project work. The study is part of an on-going research project and has developed from work carried out in 1992/3, the results of which were presented at IDATER93 (Atkinson, 1993). The research was carried out in eight case study schools selected from an initial survey of fifty schools in seven Local Education Authorities in the North East of England. The data referred to in this paper was collected during interviews with forty Year 11 pupils and their eight teachers of Design and Realisation (D&R).

Before discussing the identified factors that affect Technology project work it would seem pertinent to refer to some of the relevant educational issues concerning Key Stage 4 pupils, particularly in the context of GCSE examinations and discuss the importance of project work as a means of delivering essential elements of Technology education.

Educational philosophy would have us believe that the assessment used to judge pupils' work should not dictate the curriculum content. Examination syllabuses should be designed to develop capability and test competence (SEC, 1986; NEAB, 1993). Because of the importance of the examination results to pupils and teachers alike, the nature of assessment and its criteria tend to influence what is learnt and how it is taught. The GCSE examination system can therefore be said to have a marked effect upon the nature of the work carried out by the pupils targeted in this piece of research.

At the heart of Technology education is the design process - the activity of designing and making.

Capability in Technology involves a complex integration of processes, concepts, knowledge and skills (DFE, 1992). It is considered that all pupils should be engaged in these purposeful and comprehensive activities (Assessment of Performance Unit (APU), 1991; SCAA, 1994).

Projects, using a design process model, have been the main method of delivering the content of this area of the curriculum since the introduction of design activities into Technology education (Design Council, 1980; School Council, 1986). The fundamental purpose of designing is the development of outcomes of various types. Designing is an intellectually demanding process. There is a basic logical procedural strategy required when designing. The problem that pupils face is that for each new task this procedure should vary in emphasis and on the amount of time needed for each stage. In fact, even when a group is set a single task, each pupil's process should be determined by the individual nature of the developing solution. NC Technology and examination syllabuses have tended to interpret the process in a narrow, unhelpful and restrictive manner. The weakness of the models they have adopted is that they suggest that pupils are not engaged in designing unless they undergo and demonstrate each of the stipulated stages of the process. There is a tendency, therefore, for pupils to learn, and teachers to teach that designing is concerned with jumping through hoops in a pre-determined order.

Across education in general, project work and problem solving activities are seen as important aspects of teacher assessed coursework at Key Stage 4 (Scott, 1990). It is considered that this type of work has the potential to develop in pupils skills

which are difficult to assess by more traditional methods (SEC, 1987). Technology teachers accept that project work is the most suitable method of assessing the process. They have, however, found it increasingly difficult to balance the requirements to work creatively with a broad based range of materials in an ever expanding context, with the need to ensure that pupils produce outcomes of quality based on sound manufacturing skills.

For pupils, project work is recognised to have a motivational advantage over other forms of classroom activity (Down, 1986; Stables,1993). However, it is also recognised that project work can cause some pupils significant, motivational problems. Its very success can be its downfall. Project work can significantly increase the work load of the pupils. This increase can be caused by the conscientious pupil themselves or by a teacher's inappropriate level of expectation.

Motivation or the lack of it, when pupils are engaged in project work, is woven into each of the key factors which I have identified. It has been a pivotal feature of this research project for although motivation is not a pre-requisite to achieving success, success can bring about motivation, which in turn can lead to further achievement.

Attitudes towards success and failure have a significant bearing upon motivation and therefore upon project work. To identify which attitude has caused motivation or demotivation and then to determine whether it is internal or external, stable or fluctuating and whether it can be controlled or is uncontrollable is a difficult task (Weiner, 1992). The complex relationship between all these and external forces such as culture, context, parental and teacher expectations has a powerful bearing upon the situation. There are also gender differences to be taken into account. Helpless and mastery patterns of behaviour vary in boys and girls (Licht & Dweck, 1983). In Technology where many girls are lacking in confidence the potential to acquire learned helplessness is high (Seligman, 1975).

The complex relationship between the knowledge base and the procedural demands of the activity has been identified as one of the factors which affect performance. To pre-determine the knowledge and skills needed to tackle a task frequently denies the nature of the activity. Research supports the belief that knowledge acquired for a specific purpose is seen as more useful and more easily remembered. Using the "need to know" method motivates pupils to push themselves beyond their existing capabilities, but the resourcing, the teacher's own knowledge base and teacher management of such

a method is crucial to its success. Professional designers understand intrinsically that they do not need to know all about everything in a particular task. They need to know what to find out , what form the knowledge should take and what depth of knowledge is required. From my professional experience in the classroom and observing others teach design using this approach, pupils will happily move into the unknown because they trust that the teacher has the answer and the capability to overcome any problems encountered, even if this may not be the case.

Creativity

The development rather than the strangulation of creativity in pupils should be the goal of all teachers. Before and during the first few years in school children are encouraged to think creatively. By the time pupils reach Key Stage 4 and GCSE examinations there is a marked drop in their creative ability (Torrence, 1964; and others). Reasons given have either been associated with developmental phenomena, or as Gowan (1981) suggests, due to 'the extinction of the right hemisphere imagery' which he believes is caused by the over-teaching of left-hemisphere brain functions such as reading, writing and arithmetic and a lack of stimulus of right hemisphere functions.

As a supposedly creative area of the curriculum, Technology should be able to stimulate and encourage creativity (APU, 1981). Stimulation, Torrence (1972;1981) and others (McAlpine, 1988; Ochse, 1990) suggest can be achieved by teachers building a responsive environment in which there is an atmosphere of receptive learning. One in which: over-teaching and over-guidance are avoided; disparaging or destructive criticism are not used; in-depth study is provided; pupils sensory awareness is addressed and the zest for learning and thinking are kept alive. Interestingly Torrence (1981) claims that teacher creativity is not a significant factor in influencing pupil creativity although he firmly believes that teaching can make a difference to a pupil's creativity. He suggests that correct methods, materials, attitudes and relationships with pupils, all contribute to a pupil's creative development. These suggestions for the development of creativity must not be lost because of the constraints imposed by NC Technology and GCSE Technology examinations.

Based upon my professional judgement and my research I would suggest that teachers of Technology believe that they can provide the creative environment that Torrence suggests. Problems that arises are due to constraints imposed by assessment. Both NC Technology and GCSE

examinations in particular are tending to inhibit the creative development of all but a few of the pupils.

Teachers Role

Interwoven with each of the factors concerning the pupils and their project work are the teachers themselves, their enthusiasm for their subject and their willingness to accept the challenge of being part of the developing philosophy which underpins the subject must be said to have a vital role to play.

The pace and extent of educational change in schools has been considerable, both for the school curriculum as a whole and for Technology as a subject area in particular. The lack of time in which to consolidate, reflect and evaluate has impinged directly upon teachers who plan and deliver the curriculum. In particular the implementation of NC Technology has led to a general undermining of confidence felt by many Technology teachers. Beliefs that have been held, skills that have in the past been shared with pride have all been brought into question.

The need to achieve success for pupils in GCSE examinations has always been of importance to teachers but with the publication of league tables an extra incentive has been introduced. This has lead, understandably, to many teachers sticking rigidly to GCSE requirements but it has also lead to many teachers interpreting the examination requirements in such a way as to lead to inappropriate use of the design process. For teachers of Technology, there are a plethora of support materials available regarding what pupils should do when they are engaged in designing. Without a clear, balanced understanding of the activity of design the process is often misunderstood, misused and hollow. In the context of this research, those charged with responsibility for the design of Technology examinations have an important role to play in helping to develop a valid design philosophy for both teacher and pupil alike.

Data collection and analysis

The interviews

Eight Case Study Schools					
The Process	Enjoyed		Neither enjoyed or disliked	Disliked	
Achievement	Good outcomes	Average outcomes	Average outcomes	Average outcomes	Poor outcomes
No. of Pupils	1	2	3	4	5
Table 1					

The final forty pupils to be interviewed were selected using the criteria indicated in Table 1 after analysis of initial questionnaires completed by all D&R pupils in the case study schools.

Having already established, from the earlier data, the pupils' general understanding and enjoyment of the various stages of the design process the interviewer was able to target an area which had been highlighted as problematic in the questionnaires - that of communication skills. Pupils were encouraged to talk about the various forms of drawing and writing they had used in their Technology project work. Answers to these questions provided further insight into the intricate relationship between modelling skills and conceptual skills regarding the processes of designing.

Questions were also asked relating to the actual design process that had been used to complete major projects. This was discussed with pupils in some depth, starting with the choosing of the brief through to the completion of practical work and evaluation.

The relationship between drawing skills and conceptual design skills

Questions regarding drawing skills were divided into four types: sketching early ideas; careful sketch drawings during 'the development of ideas stage' of designing; orthographic drawings; presentation perspective drawings of the chosen idea. As earlier stated the relevant conceptual skills involved were also discussed. Analysis of the data for the total sample is shown in Table 2

n = 40		Comments		
Communication Skills - drawing		Drawing skills	Thought processes	General points
Early sketches	pos 37	15	12	10
	neg 23	11	9	3
Careful sketches	pos 16	4	3	9
	neg 32	12	11	9
Orthographic drawings	pos 17	6	4	7
	neg 24	11	2	11
Presentation perspectives	pos 22	11	0	11
	neg 17	8	1	8
Table 2				

It is interesting to note how the balance of positive to negative comments varied throughout the process. At the initial design stage when 'Early sketches' were being produced the balance was towards positive comments. Sixty-two percent of comments made were positive whilst only thirty-eight percent were negative. Pupils referred to having: enjoyed thinking of ideas; found it easy; believed it was necessary; enjoyed the drawing technique involved. Negative comments on the other hand pointed towards certain pupils: having difficulty in thinking of ideas; possessing poor freehand drawing skills; finding the task tedious; being unable to see the point of putting ideas down when they knew what they wanted to make.

The balance of positive and negative comments altered towards a greater number of negative comments in both the stage using 'Careful sketches' and the stage when 'Orthographic drawings' were produced. Only thirty-seven percent of the comments were positive whilst sixty-three percent were negative. Pupils referred in both these sections to difficulties associated with: working out the details; the accuracy needed in the drawing techniques; the time consuming nature of the task; and the fact that they wanted to get on with making. The few positive comments related to instances where pupils had: enjoyed working out the details; enjoyed the challenge of this type of drawing; been proud of the outcome.

The careful 'Presentation perspective' drawing produced a more even spread of positive and negative comments. Fifty-six percent were positive and forty-four percent were negative. There were those who enjoyed the drawing techniques involved, were proud of the outcome, and felt that it was a satisfactory way of completing the project. On the other hand there were those who spoke of finding the drawing technique difficult, time consuming, and even one who admitted that her older brother had done her drawing because she knew she could not achieve a satisfactory outcome.

The relationship between writing skills and conceptual design skills

Questions referring to writing were divided into three types, those relating to: annotation of early sketches in order to explain ideas and thoughts; careful lettering for headings, title sheets, orthographic drawings etc.; the written evaluation at the end of a project. Analysis of the data for the total sample is shown in Table 3.

n = 40		Comments		
Communication Skills - writing		Writing skills	Thought processes	Time
Annotation	pos 30	0	28	2
	neg 27	12	13	2
Titles etc.	pos 25	8	13	4
	neg 20	6	6	8
Evaluation	pos 20	2	18	0
	neg 48	6	33	9
Table 3				

The overall balance between positive and negative comments regarding the 'Annotation' of early sketches was fairly equal. Fifty-three percent of the comments were positive and forty-seven were negative. However, marked differences appeared within those figures. With regard to the writing skills needed in annotation, all the comments made were negative. The majority questioned referred to the untidiness that resulted from writing notes alongside their drawings. However, when it came to the thought processes involved during the production of annotations, twice as many of the comments were positive as negative. The positive comments suggested that pupils had: found it easy to think what to write; felt it was important to be able to communicate thoughts to others; believed it was a good way of explaining how things worked; explained that it could help them to clarify details. The negative comments concerned not enjoying having to think what to write and more explicitly, not understanding how things worked. Very few of the sample mentioned the time taken to annotate their drawings as being an important consideration. Only two pupils suggested that annotating was quick and easy, whilst another two did state that it was tedious if it was done for the sake of writing something.

Completing the careful lettering i.e. 'Titles' needed in their design work was once again reasonably balanced between those who gave positive feedback and those who saw the task in a negative light. Only eight pupils actually referred to having enjoyed the technique involved although thirteen others suggested that they were either proud of the outcome when they had finished or suggested that it was worth the effort as it enhanced the presentation of the project. Negative comments referred to difficulties concerned with the accuracy

needed and the time consuming nature of the task. Others admitted that they avoided doing it. The methods used to achieve this form of lettering varied. There were those who used computers because it was quick and easy to achieve a satisfactory result. There were those who used stencils in order to help them achieve a more accurate outcome, and there were those who preferred to do the lettering freehand, either because they got satisfaction from their endeavours, or because they wished to display an individual 'flavour' to their work. This they suggested could not be achieved by using either a computer or a stencil.

Evaluation, as expected (Atkinson, 1993) proved to be a stumbling block for many pupils. Twenty-nine percent of the comments regarding the process and the skills needed were positive whilst seventy-one percent were negative. Only one pupil out of the total sample suggested that they did not mind writing an evaluation whilst another said that it made up for their lack of drawing skills. The vast majority of the negative comments were concerned with the thought processes involved in producing an evaluation. Although nine pupils did refer specifically to the time consuming nature of the task. The major difficulties which pupils cited were to do with their lack of understanding regarding what should be written. Aspects which proved problematic were: explaining their thoughts; thinking of positive and negative things to say; being able to criticise their outcome when they thought their outcome was suitable. A number of pupils disliked having to reflect upon failure whilst others did not enjoy having to find out what others thought of their solutions. There were those who quite openly stated that the only reason they did an evaluation was to gain marks for their GCSE project.

This dislike of the evaluation process supports the earlier data collected from the questionnaires (Atkinson, 1993) when 'making' was ranked first by eighty-five percent of the sample, 'design' second by seventy percent of the sample, 'research' third by fifty-five percent of the sample and 'evaluating' was ranked fourth by seventy percent of the sample.

Manufacturing skills

Manufacturing skills had been targeted in the earlier questionnaire although specific questions regarding whether pupils had enjoyed making their project, whether it was finished or not, and whether they were pleased with the outcome were all discussed during the interviews.

Of the total sample just over half of the sample had finished their practical work on time, whilst five others had almost finished. Six explained that they were "no where near finished" and five admitted that they had not even started. Twenty-six pupils spoke of having enjoyed the making aspect of their project with only seven others referring to the fact that they had disliked the manufacturing stage of the process. Reasons given for not enjoying this aspect of the project were mainly associated with the pressure of examinations and poor time management. On the positive side, the comments could be grouped into those who had enjoyed: the construction processes involved; those who had enjoyed using their hands and working with materials, and those who were proud of the outcome. This later group formed thirty percent of the total sample. What was quite interesting about this group was the fact that a number of them suggested that it was not necessarily the making of it that had caused them pleasure, rather the possession of the finished outcome. These pupils showed that they were able to motivate themselves to tackle something they did not find particularly enjoyable by looking forward to possessing something they would be proud of.

Those who had had difficulties or were disappointed with the making aspects of their projects cited inaccuracy as the most common cause of their dissatisfaction. Pupils suggested that the cause for the inaccuracy was: a lack of process skills; inaccurate marking out ; things not having been worked out carefully enough in the first place; and a lack of time management particularly at the design stage leaving them with too little time to finish the practical work to a satisfactory standard.

The effects of giving pupils a context to work in as opposed to freedom of choice

Two different approaches were adopted by the schools when it came to chosing a major project. Of the total sample of forty pupils, thirty were given the freedom to choose their own projects whilst ten were given a context within which to work. In one school this context was set by the Examination Board and in the other instance the school set its
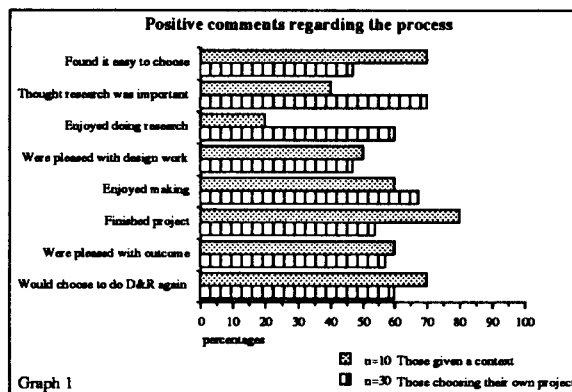
Graph 1

own. The obvious benefits to the school were in managing the resources that might be needed both at the research stage and the manufacturing stage. In the context of the design process, as far as the pupils were concerned the benefits or otherwise of these two approaches can be seen in Graph 1.

Those who were given a context within which to work found it easier to select a project than those who were given freedom. However, a negative effect was identified at the research stage for those who were given a context. Analysis of the data showed that this group did not believe that research was important nor did they enjoy carrying it out. When it came to the design work both groups were equally pleased with their work although this only represented fifty percent of each group. A slightly larger proportion of the pupils who were given the opportunity to choose their own projects enjoyed making them, whilst there was a significant difference between the two groups when it came to finishing the manufacturing stage on time. Eighty 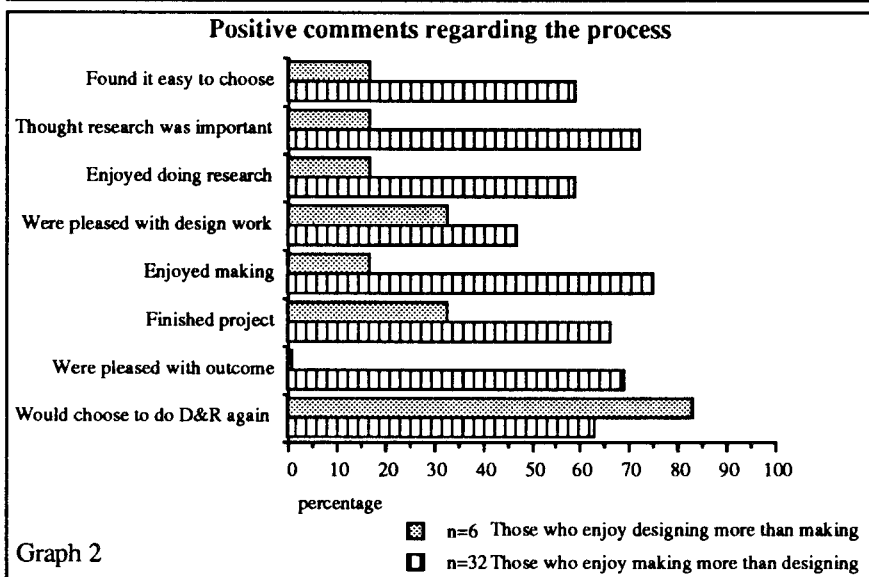percent of the 'context' group finished their projects. I would suggest that this was in the main due to the fact that the projects tackled by this group were 'safe' projects. They were set well within the pupils' capabilities and the projects chosen were within areas which could be easily managed by the staff in the schools with the resources and equipment they had available. There was little difference in 'how pleased' the pupils were with their outcomes. One might have reasonably expected that those who had freedom to choose would be more pleased with their final products, but this was not the case. The results of the interviews suggested that in many instances problems arose during manufacture because of ill-conceived, unfinished design work that had led to radical changes being made during the manufacturing process. This caused a number of pupils to be disappointed with their outcome. Conversely, one could have expected some despondency regarding the outcome by those who were given their original context but this was not the case. Evidence suggested that in this case pleasure with the outcome was due to the fact that

it was work done for an examination. In the pupils' eyes it was more important that the result was satisfactory than that the artifact was something they wanted.

One of the other questions asked during the interviews was concerned with whether the pupils had enjoyed designing more than making or making more than designing. Eighty percent stated that they had enjoyed making more than designing. It had been hoped to compare the differences between these two groups as far as conceptual and acquired skills relevant to designing were concerned, but analysis of the data revealed that the two groups were very unbalanced with regard to their levels of achievement in their project work. Those who enjoyed making more than designing displayed a normal distribution with regard to achievement but the group who enjoyed designing more than making all fell into the average or below average cohort for achievement. Therefore it was impossible to make a comparison using the resulting data. See Table 4.and Graph 2.

n = 40	Perceived achievement levels				
	Very well	Well	Average	Not so well	Not well at all
Enjoyed making more than designing	1	7	16	7	2
Enjoyed designing more than making	0	0	3	1	3
Table 4					

Positive comments regarding the process

Graph 2

■ n=6 Those who enjoy designing more than making
□ n=32 Those who enjoy making more than designing

Conclusion

From analysis of the teacher & pupil data with regard to the various processes that pupils adopt in order to tackle their major projects the evidence would suggest that pupils fall into two bound categories. (see diagram 1 - overleaf)
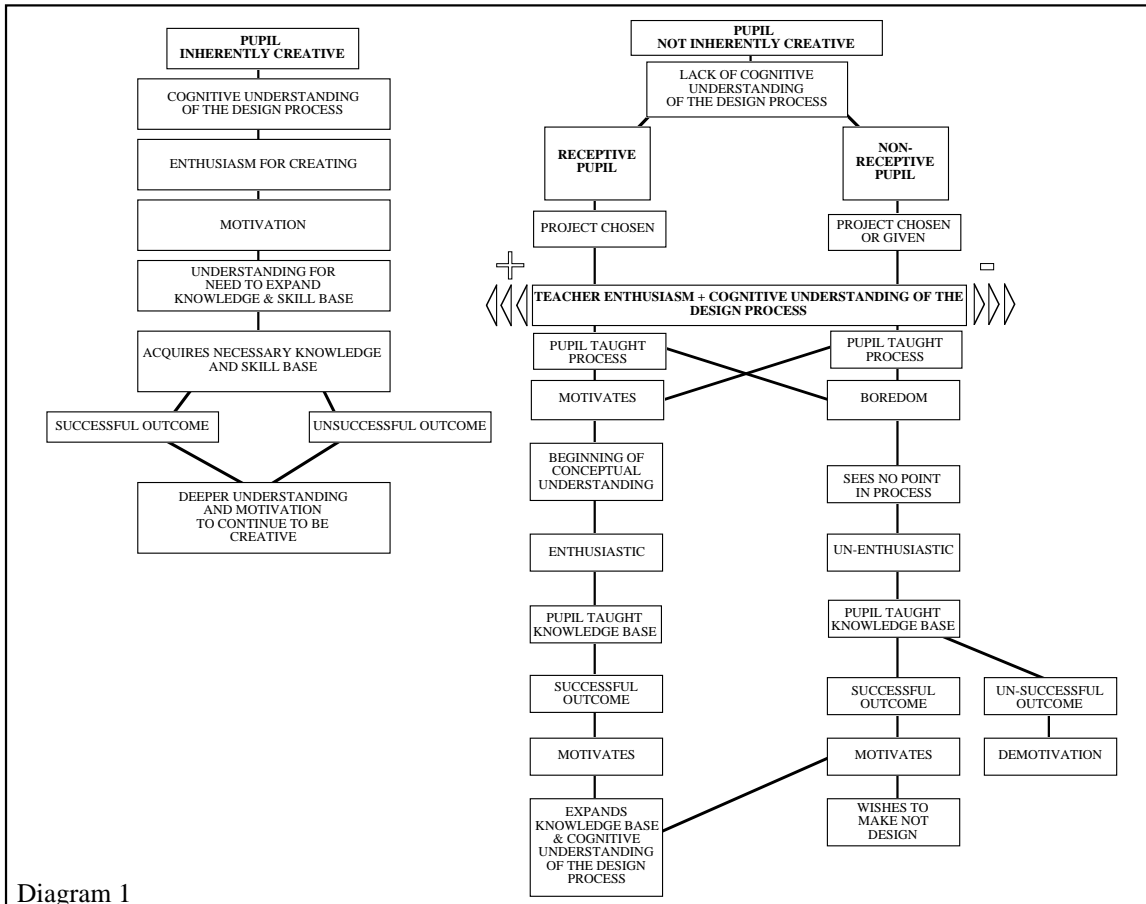
Diagram 1

There are those who are inherently creative and those who are not. Within each of these categories there are two types. The inherently creative can be divided into those who are able to create within the constraints of the GCSE examination process model, and there are those who are inhibited by such a structured approach. In the second category, that encompasses the vast majority of pupils, there are those who are not inherently creative but are receptive to learning the design process methodology that will allow them to produce creative outcomes and there are those who are not receptive and become easily de-motivated. Those who are inherently creative have the motivation to persevere however difficult the task may become. The other groups all need external encouragement to overcome their conceptual difficulties. The progress of all four groups is affected by a number of key factors specific to the task of designing and making. The complex relationship between these and other external forces such as culture, context, parental and teacher expectations cannot be underestimated. Since these factors can rarely be dealt with in isolation, I would suggest that in the context of technology project work, more often than not, one is concerned with a combination of a number or all of the following: pupils acquired modelling skills; conceptual skills regarding the process; inherent creative skills; the need for evidence for assessment causing the use of inappropriate forms of modelling by the pupils, and teacher cognition of the real process of designing.

Each of these factors is a key to achieving improvements in the designing and making tasks that are carried out by pupils at key Stage 4. But I would like to suggest that the teacher is the lynch pin that can cause the other factors to fall into place. A teacher who understands the 'real' process involved in designing can teach or guide pupils to acquire the appropriate modelling and conceptual skills, can enhance and encourage creativity, and can prevent pupils from using inappropriate forms of modelling.

It is hoped that in the next stage of this research project factors can be further defined and refined leading to the production of materials which could help to improve the performance of pupils in Technology project work.

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[1] *In order to avoid confusion and assist the reader the term 'technology' has been used to describe technology in the widest sense of the word. The terms 'Technology' and 'Technology education' have been adopted to describe the area of the curriculum associated with this research project, whilst 'NC Technology' has been used when reference is made specifically to National Curriculum Technology.*