Interactive Media for Enhancing Learning and Creativity in Design and Technology Education

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Abstract

This thesis is an exploration of the potential of interactive media to enhance learning and creativity in Design and Technology education. The work focuses on A level which is a stage at which autonomous learning becomes a significant part of the subject's pedagogy.

This research is interdisciplinary in nature, bringing together the areas of D&T education and interactive media for learning. The gap in knowledge which it targets is the development of interactive learning resources aimed specifically at the creative development of the learner. This is an area which has been given limited attention in interactive media for learning, which has tended to place a focus on declarative knowledge, rather than original thought. In addition, while D&T education research has explored issues of enhancing creativity, the development of interactive learning resources which are aimed at enhancing creativity in the subject has been limited. Yet as the literature review makes explicit, D&T is an exciting subject area for interactive media development.

Through an action research methodology involving the design and evaluation of an interactive media learning environment entitled ecoWarrior, this research explores a number of key research questions regarding the role of interactive media in enhancing creativity in D&T education. These questions include an exploration of the role of collaboration and dialogue within a computer-supported learning environment; the structuring of the learning content and interactions; issues of user control and learner autonomy; the influence of affective factors on student learning.

The contribution to knowledge of the work can be summarised as identifying specific conditions of learning which would improve the potential of an interactive learning environment to enhance learning and creativity in D&T. The original contribution to knowledge can be summarised in the following categories:

- The need to promote learner autonomy, in order to encourage original thinking in the learner. Within this the specific roles of teacher, learners and learning environment are discussed;
- The value of dialogue and collaboration to enhancing creativity in the learner;
- The specific characteristics of an interactive learning environment to enhancing creativity in the learner – namely its flexibility and its capacity to personalise the learning interactions;
- The ability of an interactive learning environment to support attitude change in the learner, both towards their own work and towards the subject studied.

Introduction

This thesis is an exploration of how and to what extent the need for creativity in Design and Technology (D&T) education can be addressed with the aid of interactive media. The reason for choosing to explore interactive media as a way of addressing creativity is firstly that research in computer based learning and interactivity has given little attention to how digital media could be used in subjects in which creativity is seen as a learning outcome. The use of technology for supporting creative thought opens unexplored possibilities for research, defining an area in which an original contribution to knowledge can be made. Secondly, as is discussed in the literature review chapters 1 and 2, interactive media is rapidly moving from being a novelty to becoming a necessity in contemporary classroom teaching and learning practices. This is why the specific ways in which learning technology is to be integrated in a subject specific way within the classroom environment needs particular attention. Specific focus is placed on:

- the changing roles of teacher, computer and learner where an interactive learning environment is present;
- affective factors which play a role in enhancing learner creativity;
- the role of dialogue and collaborative learning to developing original thought;
- elements of interactive media, which contribute to attitude change in the learner.

Chapters 1 and 2 of the thesis constitute a discussion of relevant literature in the field of interactive media and its potential to supporting creativity in D&T education. Chapter 1 sets out the issue of creativity in a pedagogical context. A definition of what creativity means and its key characteristics is provided. Such a definition allows research to derive specific conditions and factors, which need to be present in a learning setting in order for creativity to develop. Practical and research projects which have successfully utilised the pedagogical potential of interactive media in the subject of D&T are critically discussed, aiming to establish the extent to which they have addressed creativity.

Chapter 2 proceeds to an in-depth exploration of existing approaches and current research into aspects of interactive media, which are able to support the conditions and factors of creativity identified in Chapter 1. The following topics are discussed:

- Using interactive media as a tool for context building
- The role of interactive media in promoting dialogue and collaboration
- Game-based learning as a way of stimulus provision and eliciting an affective response

Alongside these, Chapter 2 discusses specific approaches to pedagogical design of interactive media learning environments. The discussion of creativity in an educational context in itself starts to suggest an approach to learning theory. The section on learning theory builds on this discussion to critically evaluate approaches varying from instructional design to constructivism and to identify the optimum approach, where creativity is part of the learning objectives.

Building upon the contextual scope of the study, Chapter 3 defines the epistemology and theoretical perspective, which overlook the research methodology adopted. The choice of epistemology and theoretical perspective are guided by the research question which chapter 1 and 2 have already started to delineate – namely – what do D&T students need from interactive media in order to be creative. In this way, the conditions and factors of creativity are the defining characteristics, which shape the nature of the epistemology and theoretical perspective adopted.

The nature of the theoretical perspective which research adopts, necessitates a phenomenological approach to the study. Students' perspective on creativity in the classroom needs to be established and their personal experiences are to shape the way an interactive learning environment is designed. Chapter 4 describes the methodology to be adopted in gathering data of students' personal experiences, as well as providing a way for this data to be applied in practice – as a series of user requirements for the design of an interactive learning environment.

Chapter 5 discusses the findings of the phenomenological study – referred to in the thesis as the Learning Needs interviews - of students' experiences of creativity in the classroom. On the basis of these findings a series of guidelines are derived which are summarised as a list of requirements for the design of an interactive media learning environment which aims to address creativity in the subject of D&T.

Chapter 6 uses the findings of the Learning Needs interviews as a specification on which the design of the prototype interactive learning environment - entitled ecoWarrior – is based. The prototype learning environment is a necessary part of the action research methodology adopted in chapter 3 – it is the desired intervention which aims to bring a qualitative change in the subject studied. In these terms, ecoWarrior is both a practical outcome of the research, which can be developed further into a full application to be used In schools and a tool for research. Through using ecoWarrior the research aims to evaluate the hypotheses and research questions emerging from the Learning Needs interviews.

Chapter 7 describes the methodology adopted in evaluating the ecoWarrior learning environment. This methodology is derived from the nature of the research questions posed in Chapter 5. It is further influenced by the nature of the research tool and intervention – an interactive media learning environment.

Chapters 8 to 10 discuss the findings of the evaluation of the ecoWarrior learning environment. The grouping in separate chapters is thematic rather than chronological, bringing together the three key types of findings arrived at. These are:

- Factors influencing autonomy;
- Factors influencing attitude change;
- Using dialogue to make learning personally relevant.

While this is a distinct categorisation of factors, the unifying theme, which summarises all of these, is affective factors in learning. Each of the chapters yields a set of guidelines, which can serve as principles for the design of interactive learning material aimed at D&T students and having creativity as one of its learning objectives.

Chapter 8 explores a series of factors, which influence learner autonomy – whether in a positive or negative way. This chapter has a particularly strong emphasis on the evolving roles of teacher and learners, as well as that of the computer within an interactive learning environment. The specific guidelines derived contribute to a fuller understanding of how to manage the balance of these entities in a way which would preserve learner autonomy and bring out original thought.

Chapter 9 is more fully concerned with specific tools of interactive media which have the capacity to act on the affective layer of learning and bring about positive attitude change in the learner. These tools are a mixture of interactive media elements and ways of structuring content. By analysing how students responded to specific elements chapter 9 gives recommendations for designing the pedagogical responsiveness of learning material aiming to elicit qualitative attitude change from the learner.

Chapter 10 explores the dialogic dimension of an interactive learning environment and the effect it has on making learning personally relevant. Personalisation being a factor for the development of creativity, chapter 10 examines how specific media elements and structures within ecoWarrior perform in allowing the learner to develop their thinking and engage in seeing their work as personally relevant.

The concluding Chapter 11 summarises the findings arrived at within this thesis. This includes both the findings of the Learning Needs interviews, derived in chapter 5 and the findings of the ecoWarrior evaluative sessions – chapters 8 to 10. Chapter 11 makes explicit the original contribution to knowledge which this research has made. It is addressed at a specific audience of educational researchers and teachers – those working in D&T education and looking for ways of integrating interactive media in classrooms – as well as targeting research in integrating creativity in interactive learning environments. Finally, the possibilities for developing ecoWarrior as a positive intervention into teaching and learning practices, are discussed and the steps taken towards making this happen are described.

Chapter 1. Literature Review Part 1 - The Need for Creativity

1.1. The need for creativity

In 1999 the Department for Education and Skills and the National Advisory Committee on Creative and Cultural Education jointly published the document All Our Futures: Creativity Culture and Education (NACCCE, 1999). The document called for national reform in view of addressing the need for the development of a creative and cultural education across all subjects in the curriculum. However it is the subjects which have creativity as part of their learning outcomes which are most directly concerned. As Design and Technology (D&T) is one of these subjects, addressing the creativity issue has become the focus of attention for educators and researchers in the field. Partly as a response to the challenge posed by the All Our Futures report, this research focuses on identifying the optimum way of addressing the issue of a creative and cultural education in D&T.

The second key element, which this research focuses on, is the increasing role of interactive media – ICT and learning technology – to facilitate learning. With initiatives such as Curriculum Online (Curriculum Online), the South Yorkshire e-learning initiative (South Yorkshire e-Learning Programme), the work of Futurelab (Futurelab - Innovation in Education), learning resources are becoming increasingly web and multimedia based, incorporating technology to enrich the learning experience and are rapidly replacing the paper based medium.

The move towards a digital future in learning is not only a more efficient way of knowledge delivery, but further meets the expectations and natural learning patterns of the current generation of learners. As Prensky identifies, learners who have grown up with digital media, are also more accustomed to manipulating and learning from a dynamic and complex, non linear medium (Prensky, 2001).

As this literature review makes explicit, the potential of interactive media for the subject of D&T is vast. Yet, while D&T is one of the most exciting subjects in terms of developments in interactive media for learning it is also a subject, which is significantly under-explored in this respect.

This literature review discusses the potential of interactive media for enhancing creativity in the D&T learner. It makes explicit how the factors necessary for the development of creativity in the D&T learner can be addressed through the tools of multimedia. Further it explores the relationship between the features of multimedia, creativity and a firm pedagogical basis, which unites these in terms of an approach to learning and teaching with computers.

Section 1.1.1 explores how the issues suggested by the All Our Futures report relate to teaching and learning practices in D&T. It further identifies the specific role, which learning technology can play in bringing about the desired intervention in terms of creativity in the subject.

1.1.1. The elements of a creative and cultural education

The All Our Futures report identifies several challenges to education: technological, economic, social and personal. These challenges describe the kind of change which is desired for the achievement of a creative and cultural education.

The technological challenge

The technological challenge is defined as the need to educate and prepare young people to work in a rapidly changing world, which is continuously shaped and redefined by technology. To make this change positive and progressive, young people need to find new ways of being creative, which reflect changes in contemporary lifestyle, technology and science. The report suggests that such change can be implemented through applying technology in a way, which meets students' learning needs, while integrating technology within mainstream education.

The All Our Futures report sees this process of integration as a task, which, in order to be successful, needs to be managed and directed by teachers. In this context, Kimbell's view is:

'...a need to reassert the personal autonomy of teachers and the importance of allowing space for these teachers to experiment with new curricula and new methods.'

(Kimbell, 2000(a) : 4)

The report calls for teachers to develop strategies for teaching and learning, which introduce technology to students in a progressive and innovative way.

Where empowering the teacher to *'experiment with new curricula'* is the aim, learning technology is the perfect tool for making this possible. While the provision of technology such as interactive whiteboards, video conferencing facilities etc. is becoming widespread in schools, it is the integration of these technologies within a meaningful structure, contributing to the curriculum, that is the real challenge posed to teachers. As educational technology research has highlighted, it is access to these facilities in terms of knowledge of how to exploit them in a learning context which is problematic, and which needs to be supplemented in the form of a teaching strategy (Laurillard, 2002(c) : 62; Loveless, 2002 : 13).

It becomes apparent that the technological challenge requires the use of learning technology to be pedagogically grounded within a teaching strategy. Properly grounded in this way technology offers enormous potential to teachers.

Researchers have explored approaches to a pedagogical grounding of instructional media. The publication of Gagne's Systems approach in his book The Conditions of Learning (Gagne, 1985) provided a systematic way of deriving instructional design by analysing the target behaviour, identifying the skills necessary to achieve this behaviour and developing the learning content on the basis of developing these skills. Boyle provides a classification of interactive media design on the basis of learning theory (Boyle, 1997(a)). Laurillard places the emphasis on the one-to-one teacher to learner dialogue as the optimum form of learning (Laurillard, 2002(a) : 81).

These are only a few examples of how interactive media has been explored in the context of learning theory by researchers and pedagogues in view of integrating it into teaching and learning practices.

However, none of these approaches provides a directed attempt at tackling learner creativity. Indeed, neither the literature of interactive media for education nor D&T education research offer much on this, leaving a gap for research to explore: how do we approach a creative education with interactive media which is pedagogically grounded?

The role of the teacher

The introduction of learning technology into the classroom environment changes the balance of interactions between teacher and learner. This necessitates a closer look at how the roles of teacher, computer and learner can be negotiated. An important tenet of the constructivist paradigm sees the teacher as a facilitator of learning - as opposed to adopting a role of imparting instruction, the teacher facilitates the learner in constructing their own pathways through knowledge and understanding (Doolittle, Camp, 1999). Taking the constructivist model as a basis, computer-based learning environments provide a rich set of cognitive tools becoming a facilitator of knowledge (Papert, 1980(b)). This in turn means that since a third element is present in the learning interactions – the computer – adopting most of the responsibilities of learning facilitator, the teacher's role becomes uncertain.

Further, while the involvement of the computer in the learning interactions has brought to life in full force the idea of self-directed learning, Laurillard is critical:

> *'...beneath the rhetoric of 'giving students control over their learning' is a dereliction of duty. We never supposed students could do that with a 'real' library; why should they be able to do it with an electronic one?'*
>
> (Laurillard in Boyle, 1997 : 206)

Crucially, however, self-directed learning bears a relationship to creativity and is therefore an essential concept for this research. In order for learners to display creative potential they need to reach a certain degree of autonomy in their learning (Rutland and Barlex, 2002; Hennessey and Amabile, 1988 : 11). This implies a diminished role of the teacher as an authority figure in the learning interactions. In exploring the potential of collaborative problem solving in D&T, Hennessy and Murphy identify that learner autonomy to some extent requires teacher absence pointing to a new focus for the learning interactions:

'the teacher's absence is a necessary but insufficient condition for peer collaboration; also important... are valuing collaboration and giving children the balance of power in the classroom.'

(Hennessy and Murphy, 1999 : 25)

This shifts the weight of the learning interactions from teacher-to-learner to learner-to-learner interactions, specifically where creative problem solving is concerned. This throws open for discussion the question of the role of the computer in these interactions as relative to that of the teacher. In this respect research literature provides evidence that game-based learning provides a non-authoritarian learning environment for students (Adams, 1973 : 9). In such an environment students are free to take risks and explore. As will be discussed further in this chapter, the possibility for risk taking without fear of censure as well as an exploratory potential are two of the key conditions necessary for the development of learner creativity (Kimbell, 2000(a); Mercer, 2000(a)).

In these terms the computer seems to have an advantage as a non-authoritarian entity, in facilitating an atmosphere of creative exploration. At the same time there can be no conception of a computer substituting for the role of the teacher. The question is how to resolve the balance of learning interactions amongst learner, teacher and computer in order to have a learning environment which is capable of supporting creativity? This question is further articulated in Chapter 6 of the thesis as a series of questions regarding user control and autonomy, and encompassing the respective roles of teacher, learner and computer within the learning environment (section 6.3.1, User control and autonomy). In addition the evaluative study of the ecoWarrior learning environment provides answers to these particular questions in Chapter 8.

Collaboration as social interaction

Placing technology in the classroom also raises the issue of collaboration. The All Our Futures report highlights one concern:

'One fear is that young people are not having enough direct contact with others and that this may affect their social development. Second, there are emergent concerns about the possible effects on young people's emotional and imaginative development.'

(NACCCE, 1999 : 22)

While this can be seen as an argument against the use of learning technology, Underwood and Underwood suggest that in fact computer based collaborative learning environments can positively contribute to social interaction:

'There are strongly expressed concerns that there may be negative psychological effects for students working individually at the computer... the majority of parents do not want their children to learn by sitting at a screen all day long. Most normal adult behaviour is interactive...there is a growing body of evidence to show that children are more likely to work collaboratively when working on computer tasks than they are on standard classroom tasks'.

(Underwood and Underwood, 1999 : 11)

Further support for the argument for a collaborative, socially situated approach to learning technology is provided by Loveless. In her treatment of the advantages of using digital technologies in the context of creativity, Loveless identifies collaboration and communication:

'working with others in immediate and dynamic ways to collaborate on outcomes and construct shared knowledge publishing and communicating outcomes for evaluation and critique from a range of audiences'

(Loveless, 2002 : 4)

Vass similarly reports the relationship between creative problem solving and a collaborative computer supported learning pair (Vass, 2002).

In these terms rather than hampering communication and social interaction, digital learning technology is seen as a way of enhancing these aspects in the learning functions they perform. This thesis explores the potential of dialogue and collaborative work to creative learning in D&T education. Specific research questions are elicited in Chapter 6, aiming to evaluate the extent to which reflective and creative thought develop in learners when using an interactive learning tool (section 6.3.1, Structuring learning content and learning interactions). Chapter 10 discusses the findings of research related to the value of computer supported dialogue to creative learning.

Economic challenge

The *All Our Futures* report poses a further, economic, challenge. This is defined as the need to prepare individuals with skills and knowledge that would allow them to work in careers where the individual's capacity for innovation is of pivotal importance.

This demand for innovation in industry necessitates the development of strategies for teaching and learning creativity as a cognitive skill. Teaching and learning creativity as a way of thinking poses the following questions:

- What is creativity?
- Can it be learned?
- In what way does it figure in the subject of Design and Technology?
- What are the cognitive activities, which students engage in within the process of designing and how can these be supported?

Looking at creativity as a cognitive skill necessitates an understanding of learning theory and a teaching strategy with a strong empirical basis, which can support the acquisition of such a skill.

1.1.2. Summary – the need for creativity

It is becoming apparent that in order to address the challenges posed by the All Our Futures report, research needs to consider several factors.

Firstly, where learning technology is to be used for the purposes of creativity, it is necessary for the computer based learning material to be conceived as a pedagogical tool. This involves seeing the computer based learning material as part of a learning environment, of which the learner and teacher are an indelible part. Within this, the respective roles of teacher, computer and learner in the learning interactions need to be reassessed. In certain aspects technology overlaps and supplements the role of the teacher, without substituting it.

In addition to this, the need for collaboration needs to be considered as an approach to pedagogy, where creativity is targeted as a learning objective. As research has identified collaboration and creativity are closely interrelated.

Accordingly, this research targets two major aspects of learning - defining pedagogy, which would make learning how to be creative possible and utilising the potential of multimedia technology to implement such pedagogy.

In order to be able to devise strategies for learning and teaching creativity it is necessary to form a working definition of creativity in the context of education. The following section focuses on providing such a definition of creativity, further situating it in the specific context of the D&T domain.

1.2. Creativity in education - definition and factors

This section examines creativity in an educational context, reviewing the definitions and key issues that emerge from major projects. It brings these together in a single model of creativity to inform design of educational multimedia and associated pedagogy.

1.2.1. Creativity in education

Several approaches to creativity are offered in NACCCE 1999. The democratic conception assumes that all people can be creative and creative thinking is beneficial to all areas and subjects of human endeavour (NACCCE, 1999 : 28). Loveless also recognises the importance of making such a distinction:

'A key issue in discussing and defining creativity is whether the focus is upon exceptional creative individuals, such as Albert Einstein or Charlie Parker, who shift paradigms in society's ways of knowing, or upon all individuals and their potential for self-actualisation through 'little c creativity' or 'possibility thinking' supporting people in making choices in everyday life'

(Loveless, 2002 : 8)

In order to claim that creativity can be nurtured and enhanced as part of everyday classroom teaching and learning practices, research needs to adopt the perspective that all learners have the capacity to be creative, and that through the use of well designed and appropriately targeted learning tools, this capacity can be developed further.

1.2.2. Characteristics of creativity

The 'All Our Futures' report defines creativity as:

'Creativity: Imaginative activity fashioned so as to produce outcomes that are both original and of value.'

(NACCCE, 1999 : 29)

Using imagination

Apart from describing it as a generative mode of thinking, the NACCCE definition qualifies imagination as looking for *'an alternative to the expected'*, through *'seeing analogies and relationships'* (NACCCE, 1999 : 29). Cropley gives a similar definition of novelty as a necessary characteristic of creativity:

'a creative product, course of action or idea necessarily departs from the familiar'.

(Cropley, 2001 : 6)

'Novelty' as specified by Cropley and 'imaginative activity', as specified by the report All Our Futures, both recognise that a necessary feature of creativity is providing an alternative to the expected, a solution which departs from the usual. Generative thought therefore emerges as a necessary part of creative thinking.

Pursuing purposes

'Creativity carries with it the idea of action and purpose. It is, in a sense, applied imagination. The imaginative activity is fashioned, and often refashioned, in pursuit of an objective. To speak of somebody being creative is to suggest that they are actively engaged in making or producing something in a deliberate way.'

(NACCCE, 1999 : 29)

This statement acts as a condition to the notion of using imagination. It conditions imagination by emphasising the need for purpose within every imaginative activity, in order to render such activity valuable. A similar notion is expressed by Cropley, who maintains that novelty on its own is not necessarily creative, unless the element of *effectiveness* is present (Cropley, 2001 : 15). He supports the idea that unless it is targeted towards achieving a specific goal, novelty does not have the necessary pedagogical value of a creative outcome. In terms of a mode of thinking, purpose is the evaluative, reflexive thought process, which goes side by side with the generative one. Creativity therefore involves two basic modes of thought - generative and evaluative, which necessarily means that a learning framework, which aims to support creativity, will have to accommodate and promote both modes.

Judging value

'...Evaluating which ideas do work and which do not require judgement and criticism. In this way creative thinking always involves some critical thinking. Understanding this is an important foundation for creative education... Helping young people to understand and manage this interaction between generative and evaluative thinking is a pivotal task of creative education.'

(NACCCE, 1999: 30)

Within the D&T learning experience judging value would be relevant at a number of stages in the creative process:

- Deciding which parts of initial research would be valuable for further creative development and which would not;
- Deciding which idea out of several initial ideas to progress and develop – i.e. – which has the most potential;
- Writing a brief and specification;
- Evaluating ideas against the specification.

Judging value as a feature of creativity complements *Using imagination*, in a way that it identifies a second 'reciprocal' mode of thought, other than the generative, underlying imagination – an evaluative mode, underlying judgement. Just as with *pursuing purposes,* such a mode of thought, which demands the learner to reflect on the generative thought process, would have implications for the teaching strategy, which will be discussed further in the chapter.

Affective factors

Affective factors in a learner's creative development can be described as being concerned with a change in the learner's attitude. Such factors are managing uncertainty and supporting self-esteem (Rutland and Barlex, 2002), supporting divergent thinking (Cropley, 2001), opportunities for play and risk taking in a non-threatening environment (Adams, 1973; Kimbell, 2000; Loveless, 2002). Loveless gives a list of characteristics in individuals, which have an impact on the learners' creativity:

'openness to experience; independence; self-confidence; willingness to take risk; sense of humour or playfulness; enjoyment of experimentation; sensitivity; lack of a feeling of being threatened; personal courage; unconventionality; flexibility; preference for complexity; goal orientation; internal control; originality; self reliance; persistence.'

(Loveless, 2002: 8)

The commonality of all of these is their affective nature (Gagne, 1985(a): 219). While the author describes these as characteristics of the individual, on the basis of evidence, which will be discussed further in the chapter, this research adopts the stance that such affective factors can be nurtured through the appropriate design and delivery of the learning environment. The following section explores in more detail some of these factors, and their effect on creativity.

Intrinsic motivation as stimulus

Hennessey and Amabile identify intrinsic motivation as a necessary condition for creativity (Hennessey and Amabile, 1988: 27). Intrinsic motivation is described as an activity in which people engage primarily out of their own interest, as opposed to extrinsic motivation, which is stimulated by a variety of extrinsic factors and goals. Hennessey and Amabile argue that these differences in motivation can actually lead to differences in creative performance (Hennessey and Amabile, 1988: 19). In fact, creative performance is seen as being in direct relationship with the nature of the motivation involved:

' 'task-involved', intrinsic motivation will lead to higher levels of creativity than 'ego-involved', extrinsic motivation...when people are intrinsically motivated, they will seek situations that interest them and that require the use of their creativity and resourcefulness.'

(Hennessey and Amabile, 1988: 13)

One effect of the type of motivation, identified by Hennessey and Amabile, is that of the learner's attitude to feedback. Intrinsically motivated children react positively to both positive and negative feedback. On the contrary, for extrinsically motivated children negative feedback produces effects of *'helplessness and amotivation'* (Hennessey and Amabile, 1988: 20).

This gives us some indication of how we can identify the learners' motivational state and the influence it has on learner creativity, specifically in the subject of D&T. The following questions can be explored:

- Are students extrinsically or intrinsically motivated? The way they choose a subject for their projects could be key to answering this question.
- Are they guided by intrinsically motivating factors such as hobbies, everyday reality, and experiences they have had in the past, which have made them think?
- At the stage of choosing an idea out of several to progress and develop, what are the priorities that they apply within the process of selecting which idea to progress?
- What place is given to how creative the idea is, what potential for development it has, or what impact it can have to resolving a problem?

Self-esteem and intrinsic motivation

Hennessey and Amabile also make a point for the need for autonomy, which the learner is afforded within the learning process. According to them, autonomy is closely dependent on the environment in which learning takes place, and more specifically on the teacher's attitude to autonomy. The authors maintain that a classroom dominated by a teacher whose attitude to the learning process is controlling, would severely suppress intrinsic motivation, self-expression and therefore self-esteem and will consequently be detrimental to creativity in students.

Qualities such as learner autonomy and self-esteem come to the forefront as conditions for the learners' capacity for original thought. A further aspect, which emerges is that creativity has to be supported by an ability to take risks and manage uncertainty:

'...these features would only be effective if students are capable of managing uncertainty. '

(Rutland and Barlex, 2002)

Motivation should therefore be underpinned by a certain degree of confidence in the learner - the confidence of being able to make a valid judgement and be able to defend this judgement before peers, as well as authority. This also involves the confidence and ability to take calculated risks, and manage the uncertainty, which inevitably accompanies these risks. On the other hand, authority needs to be balanced in such a way as to encourage, and possibly reward, such an attitude of confidence in the learner (Kimbell, 2002(a)). Questions, which arise as a result of considering the issue of self-esteem and motivation in the learner, are:

- To what extent is the D&T classroom a positive learning environment? Is the attitude of teachers in the D&T classroom controlling or does it encourage autonomy?
- Do students display self-esteem in the approach to their work, and is this manifested in a positive attitude to risk taking, and an ability to take control of their own work?
- Are students autonomous or do they rely to a large extent on the teacher for guidance?

To sum up it is clear that the characteristics of creativity as identified by *All Our Futures* are universally accepted and reinforced within research literature on creativity (Cropley, 2001; Loveless, 2002). The two main modes of thought within a creative thinking process are generative, which finds application within the activities of using imagination and being original, and evaluative, which are applied through judging value and pursuing purposes. These two major modes of thought do not exist in isolation from one another but rather work in combination, as a form of natural progression. The implication this makes for a teaching strategy is that it should incorporate both modes of thinking while also offering a pedagogical approach to managing the interaction between the two modes.

Apart from specific modes of thought, research literature on creativity in an educational context identifies a series of factors – both external and internal – which have an effect on learner creativity. These can collectively be termed affective factors since they relate to the affective layer of learning. These factors make suggestions of how the learning environment and the teachers' approach can be tailored in order to enhance creativity in the D&T learner. Research questions are specifically elicited in Chapter 6 regarding the influence of affective factors on the learner's creative potential (section 6.3.1, Affective factors which influence learner creativity). The evaluation of the ecoWarrior learning tool provides some answers to these questions which are discussed in Chapter 9.

The following section looks more closely at the issue of creativity, specifically in the subject of Design and Technology. Research projects exploring approaches to facilitating the delivery of creative education in D&T are discussed. The contribution, which D&T creativity research makes and which will be explored within this section, is that of identifying practical approaches to implementing this definition and the implications this makes for pedagogy and learning materials design.

1.2.3. Creativity in the context of Design and Technology education

This section looks at how different research and practice based projects and initiatives in D&T education have addressed the issue of creativity. The projects discussed have been selected on the basis of having creativity as part of their learning outcomes or as the focus of research. The first two projects to be discussed are directly related to the issue of creativity in D&T education. These are Nuffield QCA and The Young Foresight initiative (Barlex, 2003).

A further focus is placed on discussing projects, which use interactive media as the vehicle for delivering learning content, which targets creative development. Examples of such projects are InnoEd, and the work of Practical Action. The discussion of these projects makes it apparent that the use of interactive media for encouraging creative development is a largely unexplored subject. In this way a contextual gap is identified which is to be explored further by this research.

Nuffield QCA

The Nuffield QCA creativity research project (Nuffield QCA Creativity Research Project) aimed to identify strategies for promoting creativity in the subjects of D&T and Art and Design. The project involved interviews and discussion groups with teachers, which culminated in developing units of work for pupils. A series of guidelines were derived, serving to inform a national approach to developing creativity in a classroom context. The following guidelines for supporting creativity were identified (Rutland and Barlex, 2002):

- The activity has to be presented in a context to which the students can relate;
- The activity has to be supported by a significant stimulus which is often, but not exclusively, intensely visual;
- Focused teaching is necessary to provide knowledge, understanding and skills;
- An attitude of continuous reflection needs to be encouraged;

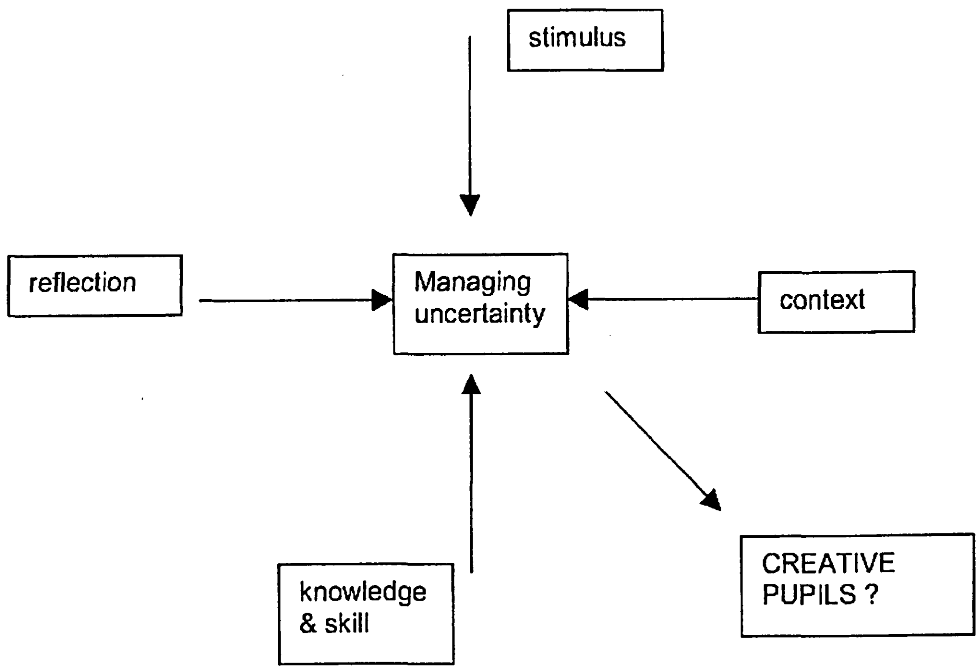

Figure 1 Features of enhancing creativity identified by the Nuffield QCA project

As is visible from the diagram at the centre of the features for enhancing creativity, is the factor of managing uncertainty and risk taking in students. The issue of making affordances for risk taking within classroom teaching and learning has become a focus of concern for educators and researchers in D&T, researching methods of promoting creativity in the subject. In his article 'Creativity Risk and the Curriculum', Kimbell highlights the essential problem with encouraging creativity within a curriculum led structure – that rewarding creativity essentially involves rewarding failure, as creativity is often *'anarchic'*, unpredictable and will result in failure before reaching what is a rare, successful, creative outcome. The issue highlighted is firstly the difficulty, which such necessary failure generates with assessment, which results in learners often playing it safe and guaranteeing a positive outcome for themselves. A further inhibiting factor for risk taking from students' point of view is the judgement of an authority figure:

'None of us will take risks with a highly creative idea if we think that any possible failure is likely to be criticised, damned and rubbished by those who hold power over us. All the evidence shows that we need to be confident that we are in a secure and supportive environment before we take risks.'

(Kimbell, 2000(a): 3)

Kimbell proposes that it is an issue of the environment within which learners work, which has the capacity to change this negative attitude towards risk taking. In his opinion, allowing teachers to take more active control over curriculum content is a key step towards implementing a creative and cultural education:

'They would need to reassert the personal autonomy of teachers and the importance of allowing space for these teachers to experiment with new curricula and new methods.'

(Kimbell, 2000(a): 4)

Therefore a form of non-authoritarian learning environment is necessary, within which learners act free from fear of failure and disapproval from an authority figure. Further, teachers need to be provided with the necessary structures and support, which allow them to explore new methods and experiment with the curriculum.

Evidence indicates that on both of these points the use of learning technology can have a positive impact. Adams identifies that a virtual world can provide a non-authoritarian learning environment within which learners are free to act without fear of censure and experiment with situations, which would be unavailable or risky to explore within a real world setting (Adams, 1973). In addition, pedagogical models of computer-based learning emerging from the constructivist perspective, offer a model for teaching and learning interactions where the teacher is predominantly seen as a facilitator of learning (Doolittle, Camp, 1999). Doolittle describes the key principles of constructivist pedagogy, amongst which the following have the most significant implications for the issue of creativity within curriculum practices:

- Students should be encouraged to become self-regulatory, self-mediated, and self-aware;

- Teachers serve primarily as guides and facilitators of learning, not instructors;

- Teachers should provide for and encourage multiple perspectives and representations of content.

(Doolittle, Camp, 1999)

Each of these tenets contributes to establishing a new relationship between teacher and learners, where the learner is more active in terms of the decision-making process, thus asserting their autonomy and addressing the issue of risk taking. The second key principle cited identifies a role for the teacher as a facilitator. In relation to this Doolittle and Camp identify the need for a reflective and *'inquiry-based problem-solving approach to teaching'* (1999: 13), which is at the heart of the social constructivist pedagogical approach. This is a significant tenet since, as will be explored further in the thesis, such an approach eliminates the hierarchical structure of learning, where the teacher is in the role of an authority figure, and promotes a reflective, inquiry based approach where the teacher's questions are informed by the learner's answers. Where the hierarchical structure to the learning interactions no longer exists, the learner's ability to become autonomous in decision-making and to deal with the fear of risk taking is naturally enhanced. The social constructivist approach therefore offers the promise of supporting creativity in the learning setting.
The role of interactive media in supporting the constructivist paradigm and therefore creativity is identified in the third tenet:

'...teachers should provide for and encourage multiple perspectives and representations of content.'

(Doolittle, Camp, 1999: 13)

According to the text:

'Experiencing multiple perspectives of a particular event provides the student with the raw materials necessary to develop multiple representations. These multiple representations provide students with various routes from which to retrieve knowledge and the ability to develop more complex schemas relevant to the experience.'

(Doolittle, Camp, 1999: 14)

The experience of multiple perspectives identifies a social approach to learning where communication and discussion based learning with peers as well as with the teacher is enabled. At the same time the author states that the key purpose of multiple perspectives is to facilitate the development of multiple representations in the learner, which form the tools of learning. The role of interactive media to enhancing learning in this respect becomes visible. Through collaborative learning applications of interactive media learners can be naturally exposed to different perspectives, idea exchange, and discussion. Moreover, one of the undisputed advantages of multimedia over more traditional methods of learning content delivery is its ability to provide multiple representations of data by bringing in a combination of media – sound, text, animation, imagery, simulation, video etc - into a unified learning environment. This capacity for dynamic representation of content in different forms would have the potential to enhance what Doolittle and Camp describe as different routes from which to retrieve knowledge.

It is necessary to acknowledge therefore that in terms of an approach to pedagogy, social constructivism offers methods and strategies, which carry the promise of supporting teachers in developing pedagogy for creativity. Further, the potential of interactive media to support this pedagogy and the factors of creativity identified so far, become apparent.

The creativity issue has been under exploration by researchers working in digital media. In addressing the question of how we can teach for creativity with the help of digital technologies, Loveless proposes the following teaching strategies:

- Awareness of the way in which creativity is related to knowledge across the curriculum;
- Opportunities for exploration and play with materials, information and ideas;
- Opportunities to take risks and make mistakes in a non-threatening atmosphere;
- Flexibility in time and space for the different stages of creative activity

(Loveless, 2002: 4)

It is evident that to a large extent these strategies overlap and support the features of creativity identified within the Nuffield QCA investigation into creativity. Thus the specific goals of instruction where creativity is concerned share strong similarities in digital media based learning and in D&T education research. We can therefore start to see the relevance of the digital medium to enhancing creativity in the learner. In providing a non-authoritarian learning environment, digital media offer an opportunity for learners to address risk taking and reassert their autonomy. At the same time, Kimbell's call for empowering teachers in experimenting with new curricula and new methods of delivery of learning content, can be addressed effectively by encouraging the use of digital media as part of delivering such content in a novel and meaningful way, stepping away from an authoritarian hierarchical structure to the learning interactions.

Young Foresight project

Similarly to the Nuffield QCA project, The Young Foresight initiative (Young Foresight) is driven by the idea of exploring alternative paths of curriculum provision, which specifically target the development of creativity in the learner. The unique feature in the Young Foresight approach is that it encourages learners to design but not make. In this way learners have the opportunity to explore future or developing technologies without the constraints of having to provide a rationale for making. It is necessary to note that Young Foresight has endured criticism in disregarding making as a natural part of designing and the exploration of physical materials, which has always been a central activity in D&T. However, the research and findings of Young Foresight are still relevant to this study in terms of their focus on how creativity happens in the classroom and how it can be supported. Far from maintaining Young Foresight to be a complete and comprehensive exploration of the creativity issue, this thesis considers it nevertheless to be a valuable contribution to knowledge, which offers scope for development, if not definitive answers.

A report by Lunn, Davidson and Murphy on the Young Foresight initiative identifies the key benefit of this approach as placing an emphasis on creative problem solving:

'Young Foresight has shifted the nature of the tasks to focus on designing rather than making, and has an implied pedagogy that should support students to become creative problem-solvers.'

(Lunn, Davidson, Murphy, 2004)

The evaluation report of the Young Foresight initiative points to the importance of the teacher adopting the role of learning facilitator, where in response the learner adopts a more active role in meaning making and directing their own learning. This type of approach as a teaching strategy is most directly implemented by leaving all decision-making in the hands of the learner. The following is an example from the Young Foresight evaluative sessions:

'The dilemmas that had been identified by Jerry and the mentor's contributions encouraged the students to engage in critical thinking about their design but decisions about resolution of the dilemmas remained with the students'

(Lunn, et. al., 2004: 9)

Similarly to the findings of the QCA investigation into creativity, such an approach reinforces the need for autonomy to develop in the learner and goes further to identify constructivism as the most appropriate approach to supporting learner autonomy.

Within their evaluative report on the Young Foresight project, Lunn et. al. identify the specific conditions for creative problem-solving and set these as criteria for evaluation:

- *'students are engaged in activities which are authentic, i.e. relate both to the actions of design in the real world and are personally meaningful;*
- *the problems are dilemmas that the students perceive, they cannot be given;*
- *the students are active, reflective, purposeful and knowledgeable: the knowledge that they use integrates both procedural and conceptual knowledge;*
- *students draw on social resources that develop as they collaborate with each other and the teacher to achieve common goals.'*

(Lunn et. al., 2004: 2)

Each of these criteria has a close relationship with the conditions for creativity identified so far in the All Our Futures report, as well as the Nuffield QCA project. Further some of these criteria are a clear indication of the approach to learning theory, which needs to be adopted. The first criteria of students engaging in authentic activities, is identical to Lave and Wenger's idea of situating learning within a real world context (Lave and Wenger, 1991(a)), which is social-constructivist by origin. The second criteria of relying on students' perceptions in meaning making rather than delivering knowledge to them as a given, is the central tenet of the constructivist paradigm – that of encouraging learning through discovery and exploration. The third criterion for creative problem solving – is once again constructivist in its description of the learner as active, reflective and purposeful. Furthermore - similar conditions of learning were identified in the Nuffield investigation into creativity (Rutland and Barlex, 2002). The fourth and final criterion once again focuses on the value of collaboration and social interaction as the basis for creative exploration.

Finally, the evaluation of the Young Foresight project identifies problem solving as a strategy for creative development. This idea has been explored in the situated learning approach by Lave and Wenger (Lave and Wenger, 1991(a)), and are supported in D&T (Hamilton, 2004; Koutsides, 2001; Hennessy and Murphy, 1999) as will be discussed in more detail further in the chapter.

There is a further element however, which has not yet been mentioned in either of the projects discussed, and which is essential to creative problem solving. Stables explores the potential of play to *'unlocking'* the imagination of the learner.

Play in D&T

As was discussed previously, divergent thinking is the form of thought most commonly associated with creativity (Cropley, 2001). Stables uses 'playfulness' as the kind of attitude, which needs to be promoted in the D&T learner in order to enhance creativity:

'...a critical feature for D&T is play that has the "what if?" attitude, suggesting simultaneously questioning and projecting into the future'.

(Stables, 2004 : 166)

Stables further quotes Bruce's description of play which is directionless and without purpose:

'...the player...wallows in the experience and in this wallowing develops a range of skills and understandings.'

(Stables, 2004: 167)

This 'wallowing' can also be described as free flow play, echoing the experience of 'flow' – Csikszentmihalyi's staple description of creative processes (Csikszentmihalyi, 1996(b): 107). Stables says:

' Of particular significance for D&T, is the way in which free flow play allows a forum for uninhibited development of manipulative skills, problem solving skills, confidence and so on'.

(Stables, 2004: 167)

Stables describes exploratory play and the kind of wallowing and losing oneself in the experience as having a clear relevance to designing, to connecting to the generative mode of thought. Play in this sense can be seen as the necessary stimulus, which involves the learner in the activity (NACCCE, 1999; Rulland, Barlex, 2002). In Stables's own experience as a teacher the ideas on a project 'began to flow' when the subject was dealt with in a 'playful' manner - i.e. - when one of the pupils started throwing in humorous and lateral suggestions for the bag project such as *' rat bag'* or *'tea bag'*. Several key conclusions can be made on the basis of Stables' research into the potential of play to creativity. Firstly play allows the learner to 'wallow' in the experience - in this way developing skill and confidence in creative exploration. Play can also be seen to provide a context for designing, a place for exploring ideas for asking 'what if?' In the case of 'designerly play' the player is actively creating new futures, which relates play to the constructivist approach to learning, where the learner is actively constructing meaning. Further the 'what if' attitude to exploration combined with the feeling of wallowing in the experience contribute to a mode of thinking which can best be described as creative problem solving. It starts to become clear therefore that creative problem solving is a key strategy, which has the potential of becoming the basis for pedagogy for creativity in an educational context (Hennessy and Murphy, 1999; Lunn, 2004).

It is further important to note that the elements of humour and spontaneity, which playfulness carries can inspire ideas, by triggering divergent thinking in the learner. As Stables identifies, it was only when learners started to become playful and humorous with their ideas that they became truly creative and original.

Research literature in the affective factors of learning with computers has similarly identified that humour and spontaneity are essential elements for creativity to develop (Vass, 2002). The potential of interactive media to support the element of stimulus in a mode of playful engagement will be discussed in more detail in the section 'Game-based learning'.

1.2.4. Interactive media projects targeting creativity in D&T

So far the focus of discussion has fallen on projects, which tackle the issue of creativity in D&T. However, since the relevance of interactive media to enhancing creativity has been identified, it is necessary to explore interactive media projects in D&T, which specifically target the issue of creativity.

The potential of interactive media to the subject of D&T has been explored in some respects. Standalone CD ROM applications have utilised the potential of interactive media to deliver content to D&T pupils, on the premise of self-directed, resource based learning. Such examples are the work of the Technology Enhancement Programme (TEP – Technology Enhancement Programme), and the work of the BBC curriculum online initiative (BBC - Schools, Learning Resources for Home and School). While these applications undoubtedly have educational potential, they do not address directly the issue of creativity in D&T education. The majority of multimedia for learning targeted at D&T is content rich and content driven, however lacks the necessary pedagogical approach to interface sufficiently well with teachers and learners and thus to become part of classroom teaching and learning practices.

Further, while their resource-based approach may work on the level of self-directed individual learning, the potential for a creative output is limited. One key issue which is yet to be addressed and which is conspicuously lacking from such applications, is the collaborative aspect of the learning interactions, which as has been identified so far in the literature on creativity in an educational context, is a key factor for creative development (Hennessy and Murphy, 1999; Lunn et. al., 2004; Koutsides, 2001).

A further factor is that of the level of interactivity, which a learning environment affords. Where the issue of creativity is concerned, specifically with reference to learner autonomy and the need for an active involvement of the learner, describes the appropriate level of control, which an interactive learning environment should be aiming for:

- *'Allowing the restructuring of content - this could mean for example - altering the sequence and structure of the material*
- *The possibility to create new content – recognised as the fourth and highest level of learner control. '*

(George Bekier – Interactivity, Navigation and Learner Control in Educational Multimedia)

Such level of interactivity is missing from interactive media for learning in D&T. This identifies a gap in research in the area, as well as a gap in the practice of multimedia design for learning. Accordingly this research explores this area through a practical intervention which aims to provide answers to both the practice and the theory of learning technology design for creativity in D&T.

A few interactive media projects targeted at the D&T subject area have been identified which can be described as a good effort in addressing the creativity issue in D&T. These are InnoEd – a virtual learning environment for learning in D&T and Practical Action – a website dedicated to providing context to learners about sustainable and eco design. The following sections discuss the value of these projects from the point of view of creativity in an educational context.

Practical Action

Practical Action (Practical Action – Education) - an initiative founded in 1966 - aims to address the issue of sustainable development in people's lives (fig. 2). The work of Practical Action is concentrated in regions of the developing world – Sri Lanka, Kenya, Zimbabwe, Sudan, Peru - aiming to reduce poverty by using technology in a small scale sustainable way. A section of the project targets the educational sector, aiming to raise generations of learners who are aware of the issues of sustainability and are capable of using such knowledge to solve real world everyday problems. The initiative is an extensive web resource, of which the Sustainable Design Award is aimed at A level students and The Sustainable Technology Education Project (STEP) is aimed at key stages 3 and 4.

The initiative is interesting to this research from the point of view of being targeted at the D&T curriculum and in the creative outcome, which is required, promoting original thought in the learner, as well as in its use of digital media. In providing such context oriented content, and combining this with the stimulus of interactive media, the work of Practical Action has the potential to address two of the key criteria for creativity identified – stimulus and relevant content. The following discussion of the two projects aims to explore whether and to what extent the challenge of creativity has been addressed.

Figure 2 The Practical Action initiative – a web resource aimed at introducing sustainability to A level D&T learners

STEP – Sustainable Technology Education Project

STEP (Practical Action – Sustainable Technology Education Project) is an online educational resource aimed at D&T key stages 3 and 4 of the National Curriculum. It provides detailed case studies of products, services and issues surrounding industrial production and design from the point of view of sustainability and eco design. The case studies are supported by structured tasks and activities, which provide opportunities for learners to actively engage with the content. The activities are structured to include background information and context, a brief and specific learning outcomes.

Learning in context

The context, which STEP provides for learning is rich and varied in its sources and perspectives. Packaging for example, is seen from the point of view of the intervention which a designer can make to improving sustainability, but also from the point of view of the service which provides it, which concerns issues of transport, the material used and end of life. In these terms the content provision is fully situated in the authentic activities of the subject setting – i.e. - the practices of designers in the real world as well as the issues in industry which need to be addressed.

Pedagogical effectiveness and interactivity

While the contextual provision, which the web resource makes is rich and varied, it makes limited use of the possibilities which interactive media offers for content presentation and manipulation. Firstly, the media used are predominantly written, linear text supported with imagery. No use is made of other possible forms of representation, such as animation, simulations, sound and video. This limits the educational potential of the learning experience. As was identified, one of the primary tenets of the constructivist paradigm involves dynamic, multiple representations of content, which aid the learner in meaning making and internalising knowledge (Doolittle, Camp, 1999).

Furthermore, while the resource deals with the kind of content, which naturally would benefit from collaborative discussion, the learning environment does not support any collaborative features. Such features could be an online forum, videoconferencing, email, or even the structuring of activities to include discussion with teacher and other learners.

The learning environment involves tasks and activities, which utilise a distinctive pedagogical structure, within which we see a visible brief, learning outcomes outlined and teachers' notes. However no possibility is afforded for the learner to change or add to the content of the learning environment (Bekier, 2005). Thus, while the learning environment is web based, it offers only the very minimum of possibilities for learning with multimedia and therefore learning for creativity with multimedia.

The learning environment's benefits are primarily to be found in the richness of its content. However there is little evidence that constructivist learning is truly supported or that learning with the STEP resource could become socially situated. With these key factors missing, the potential of the learning resource for supporting creativity is limited.

Sustainable Design Award

The key strength of the Sustainable Design Award web resource (Sustainable Design Award Online) is that it provides specific design briefs to A level students. The promise of reward is an added advantage since, if engaging with any of the design briefs suggested, learners can enter their project for the Sustainable Design Award and can potentially win the award. The design briefs are detailed, however they are not prescriptive – they only go as far as identifying a direction of thought. They further offer help with initial research, by identifying an area of the world, or a community, which can benefit from a sustainable solution. In addition to this the SDA website makes it accessible for learners to contact Practical Action personally and request the information, which they need. In these terms the learning resource opens possibilities for authentic, real life research into design issues and contexts. It further improves the communication and social skills of learners by placing them in a situation where they have to communicate with the organisation in order to research their topic appropriately.

An added advantage exists in providing this intermediary link with the community, which learners are designing for. By being in touch with the authentic needs of the community, as well as communicating directly with the voluntary organisation – Practical Action – learners find out more and have the opportunity to become sympathetic to the lives of the community they are designing for. This not only makes the activity more authentic and situated in a real world context, but also works on the affective layer of learning of students. As identified by Hennessey and Amabile – this is an essential factor for the development of creativity, and can also be classified as added stimulus supporting the authentic activity, which the Nuffield QCA project identifies as essential for creativity (see fig. 1).

Pedagogical effectiveness of multimedia and interactivity

It is evident that the SDA has some evident advantages in terms of strong content and a direct link to a live resource on sustainability. However, similarly to the STEP project, the SDA uses predominantly narrative, images and hypertext as a way of delivering information. The method of delivery for learning which Practical Action have utilised is a one way transmission model, where the learner is offered information, but has no way of manipulating or adding to the content. No direct engagement with the learner is built into the website other than browsing.

Furthermore, while the potential for discussion, which the content provides is enormous it is rarely if at all facilitated through the use of technology. In other words while it is possible for dialogue and interesting discussion to develop, there is no interface which facilitates such interaction.

While the opportunity for creative problem solving exists through the contextually rich content provided, the interface and the digital medium used are not utilised in a way which contributes to actively engaging the learner whether this is in discussion, ideas exchange, or idea generation.

InnoEd

InnoEd is a virtual learning environment (VLE), which aims to enhance learners' creative thinking through supporting idea sharing and dialogue in an online, synchronous communication model (Thorsteinsson, G.; Page, T., 2004). The VLE supports a course in the subject of Innovation Education – the equivalent to the subject of D&T in the UK. Learners communicate and share ideas within a virtual learning environment. An open distance-learning model is employed.

One of the most progressive features of the project is its exploration of collaborative approaches to learning. Pupils work in groups and negotiate their ideas. Remote and concurrent access to content means that more learners with a varied experience of the subject discussed can share information and express opinions on the information. Pupils have access to a wider variety of different points of view and have the possibility to enrich their learning experience. The project reports on evidence of increased engagement of pupils however there is no concrete evidence on whether students are learning or if this engagement leads to creative thinking.

InnoEd applies some of the key factors of creativity identified through research in the area of D&T education. However, at present the project is not concerned with developing a teaching strategy, or a coherent pedagogical approach. The project needs to consider these areas if it is to progress from being an exciting exploration of what technology can do and look at ways in which technology can be tailored to become part of a learning environment.

In addition, the transition from teaching the subject of Innovation Education within a traditional classroom setting to teaching it through the use of a virtual learning environment needs to involve reassessing the teaching strategy employed and the delivery methods, in a way which suits the medium of delivery and the new opportunities for engagement of the learner which are implicit within the VLE. A coherent teaching strategy is yet to be delivered by the project. This identifies that the effort in interactive media for learning where creativity is concerned needs to concentrate on identifying and applying a coherent pedagogical approach.

1.2.5. Summary

Each of the projects discussed in this section, contribute to our understanding of the present state of the use of interactive media in D&T education. However, the potential of interactive media is yet to be fully explored in the context of learning and creativity.

Content driven and content-based resources such as those generated by Practical Action – the SDA and STEP – have invaluable potential to opening new horizons for learners. They expose the learner to approaches to designing which are rich in possibilities for creative exploration and original project work. Despite this advantage however, these projects are yet to start making effective use of the interactive medium as a tool for pedagogy. Two of the key weaknesses are that the possibility for learners to manipulate and add to content is not allowed for. This defines STEP and Practical Action as interactive resources rather than learning environments. Secondly, there is no visible structure or support for collaborative work and exchange of ideas, such as are necessary for creativity to develop.

Amongst the projects discussed only InnoEd can be described as making full use of the technological potential of interactive media. It uses collaborative media in a successful way to promote idea exchange and discussion based project oriented work. While InnoEd is a good example of the use of technology, questions remain to be explored which the project does not address. Such questions are how to create the optimum conditions for supporting collaborative creative discussion for students? Further, within an environment, which involves the computer as the medium for learning delivery – what is the optimum role which the teacher can play? These can be summarised as issues related to the pedagogical design of a learning environment, which aims to support learning and creativity. These questions are refined and summarised in Chapter 6 (section 6.3.1, Structuring learning content and learning interactions). Chapter 8 of the ecoWarrior evaluation provides answers regarding the role of the teacher and Chapter 10 discusses findings relating to the role of dialogue in computer supported learning.

It is evident that a closer look is necessary at the way interactive media design can facilitate learning and creativity in D&T. The following chapter aims to explore in more detail specific types of interactive media – narrative, interactive and discursive - in terms of their pedagogical potential to support creativity in the D&T learner.

1.3. Summary of chapter

To summarise approaching creativity as a form of learning necessitates taking into consideration the issues particular to the subject setting, the advantages and limitations of the medium of delivery and identifying an approach to learning theory which will provide the pedagogical grounding for learning environment design.

The exploration of the issues of creativity in an educational context, highlights the need to see creativity as two reciprocal modes of thought – reflective and generative. Both of these modes of thought demand a stimulating environment, which further offers the relevant content for the learner, encourages them to reflect and is able to support and encourage creative risk taking. The need for stimulating, diverse content, which includes a social dimension as well as has a natural flexibility in the learning interactions, which develop, makes digital media and computer based learning appropriate to consider in addressing these needs.

Several interactive media projects targeting the subject of D&T and the issue of creativity were discussed as case studies providing an outlook of the current state of the art on educational multimedia in D&T. However, a gap has been identified in the knowledge, which these learning environments provide of how to design multimedia learning with creativity in mind. Firstly creativity was rarely identified as a specific learning objective of the learning environments. Secondly, the use of the digital medium was limited, rarely involving higher order interactivity such as creating new content and restructuring of existing content (Bekier, 2005)

Chapter 2. Literature Review Part 2 - The Role of Interactive Media

2.1. The role of interactive media in supporting the key factors of creativity

2.1.1. Introduction

The projects and documents targeting creative development in an educational context discussed have identified several key factors conditioning creativity in the learner. These factors can be summarised as context, reflection, stimulus and learner autonomy. The literature review on creativity in the subject area of D&T has discussed both the way these factors originated (NACCCE, 1999; Nuffield QCA) and how successfully they have been implemented within projects targeting learning and creativity in D&T education - Young Foresight, SDA, STEP, InnoEd. This section discusses the potential of interactive media to implement these factors in an educational context and in this way to enhance the learning experience.

2.1.2. Context

The Nuffield investigation into creativity pointed to providing the relevant context to the learner as one of the key conditions for enhancing learner creativity. This section explores the way interactive media implements context building and the educational potential of such context.

Giving context to a task or learning activity can be thought of as relating knowledge of the subject studied to the learner. Making the context 'relevant to the learner' (Rutland and Barlex, 2002) can be interpreted as telling the story by using terms, situations, examples, which the learner is familiar with or which are close to the learner's reality. This method of narrating and using familiar situations helps the learner relate new knowledge to their previous experiences. As an approach to learning, relating new information to past experiences corresponds to experiential learning, and has been described as a factor for facilitating creativity in itself (Weisberg, 1988). Boyle relates experiential learning to discovery-oriented, constructivist approaches to learning with interactive media (Boyle, 1997(a)).

Having proposed narrative and story telling as context building tools in an educational capacity, the research needs to further focus on the possible contribution, which interactive media can make to this. The following section deals with this aspect of interactive media in particular.

Interactive media as a tool for context building

In her review of the relationship between creativity and new learning technologies, Loveless accounts for several features, which make ICT unique in terms of the potential it offers for learning – these are – *'provisionality, interactivity, capacity, range, speed and automatic functions'*.

(Loveless, 2002: 12)

She maps the features of ICT onto the All Our Futures framework for creativity (see fig. 3).

Features of ICT	NACCCE Framework for Creativity
Provisionality Interactivity Capacity Range Speed Automatic functions	Using imagination A fashioning process Pursuing purpose Being original Judging value

Figure 3 The relationship between features in ICT and those of creativity, Loveless, 2002 : 12

In this comparison we can see that the factor of 'capacity' corresponds to this of 'pursuing purposes' and that of 'range' corresponds to 'being original' – therefore in order to have purposeful originality, a learning environment needs capacity and range. Loveless describes the potential, which ICT has for capacity and range:

'ICT demonstrates capacity and range in the ways in which it affords access to vast amounts of information locally and globally in different time zones and geographical places. The speed and automatic functions of ICT allow tasks of storing, transforming and displaying information to be carried out by the technologies, enabling users to read, observe, interrogate, interpret, analyse and synthesise information at higher levels.'

(Loveless, 2002: 12)

Thus the capacity for viewing context in a fast, dynamic way is at the learners' fingertips, opening more opportunities for manipulating and reinterpreting context. ICT therefore makes a unique contribution to context building, which has positive pedagogical implications.

Loveless also relates the capabilities of ICT to situating learning within a realistic context, as described by Lave and Wenger (1991(a)). She maintains that ICT allows learners to:

'demonstrate such capability in knowing, not only how to search the world wide web or to manipulate a digital photograph, but also why and when such skills might be appropriate for different reasons in different situations to solve different problems.'

(Loveless, 2002: 12)

Thus Loveless sees ICT as having potential in providing context through allowing the learner to meaningfully explore, challenging sceptics' views of the internet as a space for surface browsing. ICT therefore is a better medium than any available for situating learning.

Narrative media design

While as we have seen, sufficient evidence exists to support the relevance of narrative to learning and meaning making, Laurillard highlights an issue with narrative delivered through interactive media. She points to the need for narrative structure as fundamental to comprehension. Through the use of hypertext interactive media undermines this structure. A dichotomy develops therefore, where:

'one of the key benefits for interactive media is seen as being the lack of imposed structure, giving much greater freedom of control to the user'.

(Laurillard, 1998: 230)

Yet, in the design of any multimedia learning material, which involves a narrative element, the question is:

'...how to manage a medium that undermines its [narrative] power if it is to succeed in an educational context?'

(Laurillard, 1998, 230)

Laurillard uses the MENO project (Multimedia Education, and Narrative Organisation), as an exploration into the learner's patterns, strategies and difficulties in meaning making within a multimedia structure. The key focus of MENO is the way the provision of narrative structure within a multimedia environment can aid the learner in meaning making. Following are the key guidelines constituting the framework for the design of narrative into interactive media learning environments as identified by Laurillard (1988):

- Make narrative explicit as a series of sub-goals
- Active learning through exploration
- Closure on the task is needed – how are they to know if they have achieved what was intended?

(Laurillard, 1998: 237)

In this third guideline for pedagogically effective narrative structure, Laurillard suggests that a 'discussion' on the topic investigated can be offered to the learner as a form of closure to the investigation. This is an expert's analysis of the issue – in effect a given answer to the issue, embedded within the system.

Having such expert feedback built into the system is in its essence exposition and reception learning, where knowledge is given to the learner. This goes against the constructivist approach. In addition, considering the emphasis which this research places on autonomy as a necessary factor for creativity, it is necessary to consider the possibility that such 'expert feedback' could have a negative effect on the learner's independence of thought. Expert feedback which is predetermined by the system and merely given to the learner as ready made knowledge could provide an easy solution to the problem. This could inhibit learners in being assertive about their own solutions, or indeed looking for their own solutions. The value of expert feedback could therefore be seen as disputable, when considering learner autonomy. The role of feedback given from an authority figure is further examined by this research, by exploring and evaluating the role of feedback from the teacher, and the nature and value of teacher intervention within an interactive learning environment (sections 8.3.1 and 8.3.2).

Narrative guidance and narrative construction

In the same vein of exploration into the optimum approach to designing narrative for learning Plowman, Luckin, Laurillard and Stratford (1999) identify the issue of freedom to explore which hypertext creates – on the one hand such freedom is liberating, on the other it can result in confusion. In answer to the challenge of establishing the optimum response to this problem, Plowman et. al. explore with two key elements – narrative guidance and narrative construction.

Narrative guidance represents the specific design features within an IMLE, which aid meaning making in the learner. Narrative construction on the other hand is the cognitive processing, which is performed by the learner in interpreting the narrative, making connections and making the learning content personally relevant.

Three types of narrative guidance were experimented with:

- Linear version;
- Resource based learning;
- Guided discovery learning (GDL) - combining guidance of the type offered by classroom teachers with the benefits of an interactive medium.

Plowman's observations identified a problem with linear narrative when used in a multimedia environment:

'this narrative seduction works well in traditional linear media such as films but is less appropriate for IMLEs because it doesn't maximize the potential benefits of an interactive medium or the interactivity offered by a good teacher and so is less suitable for learning'.

(Plowman et. al., 1999: 311)

The guided discovery version provided initial questions and guidance in identifying a line of enquiry. Once learners chose a line of enquiry however, they were free to browse and explore. In these terms the GDL version provides narrative guidance, as well as help in narrative construction.

GDL appears to be the optimum choice since it has the most potential in simultaneously maintaining a strong narrative structure, which aids narrative construction and supporting learner autonomy in adopting the role of the teacher. In these terms the GDL example of guidance provision seems to be closest to the idea of the teacher in the role of facilitator of knowledge, not instructor, which is a feature of constructivism, and a necessary condition for creativity. Chapter 6 draws out specific research questions regarding the pedagogical effectiveness of a discovery based learning environment (section 6.3.1, Structuring learning content and learning interactions). In addition, the learning environment developed as part of the empirical study of this research – ecoWarrior – implements a GDL approach to narrative guidance and structure (see Chapter 6). The findings of research described in Chapter 8 provide some answers regarding the value of GDL to creativity and learner autonomy.

The potential of narrative as motivation

One advantage of the digital medium to creativity is its ability to elicit emotional response from the learner. In the exploration of the reasons why game based learning is engaging Prensky identifies narrative as contributing to stimulating the learner's emotional response (fig. 4):

The elements that make computer games engaging
(adapted by Attewell and Savill-Smith 2003 from Prensky 2001)

Characteristics of the computer game	**How characteristics contribute to players' engagement**
Fun	Enjoyment and pleasure
Play	Intense and passionate involvement
Rules	Structure
Goals	Motivation
Interaction	Doing (ie the activity)
Outcomes and feedback	Learning
Adaptive	Flow
Winning	Ego gratification
Conflict/competition/challenge and opposition	Adrenaline
Problem solving	Sparks creativity
Interaction	Social groups
Representation and a story	Emotion

Figure 4 The elements, which make computer games engaging; Prensky, 2001

Creativity is facilitated where emotional response is involved and the type of learning can then be identified as belonging to the affective layer, and being related to a change in attitude. This is supported by Hamilton who identifies specifically from a D&T perspective:

'...a story has the power to fire children's imaginations, stimulate their creative energies, engage them with real world issues. The holistic nature of stories enables pupils to make connections and gives meaning to knowledge and understanding'.

(Hamilton, 2004: 89)

So far the literature review has discussed the potential of narrative in the form of digital media to promote learning and creativity. Apart from narrative however a further element of significant value to supporting creativity are media which support dialogue and collaboration. The following section discusses approaches to designing collaborative media and their relationship to creativity.

2.1.3. The need for collaborative learning and collaborative problem solving in D&T - The role of media in promoting dialogue and collaboration

Vygotsky's theory of language as a tool for thinking has influenced D&T research in exploring collaborative learning. This section reviews relevant research in the area of collaborative learning, from the point of view of its potential for creative problem solving within the D&T discipline. In addition models adapted for the design of interactive media, which support collaborative work are discussed, from the point of view of the potential for creative exploration they offer to learners.

As a starting point for an exploration of the significance of collaboration and dialogue to learning a closer look is necessary at Vygotsky's theories of language as a form of thinking. Vygotsky identifies a direct relationship between using language and developing creative solutions to problems, through seeing relationships other than the obvious:

'The most significant moment in the course of intellectual development, which gives birth to the purely human forms of practical and abstract intelligence, occurs when speech and practical activity, two previously completely independent lines of development, converge.'

(Vygotsky, 1978(a): 24)

Vygotsky's experimental work led to the conclusion that:

'...speech not only accompanies practical activity but also plays a specific role in carrying it out'

(Vygotsky, 1978(a): 25).

According to Vygotsky, speech actively contributes to finding solutions to a problem. From this point of view, the development of language is responsible for the development of thought in people. On the basis of observational work, Vygotsky is able to conclude that a child, by accompanying its actions with speech, in fact creates new and more versatile solutions, which would otherwise not have been immediately visible. As a result of using language the child is able to use as tools not only immediately available objects - she engages in a search for stimuli such as can be useful in the solution of the task and the planning of future actions. In this way Vygotsky illustrates the creative potential of language. It is a tool for searching for solutions other than the obvious, it is the means of finding paths to original solutions and the means by which divergent thinking – such as is necessary for creativity – is made possible.

On the basis of Vygotsky's research it is possible to see a relationship between language and creativity. Verbal expression, within a problem-solving environment, can help find alternative solutions, and see relationships other than the obvious, this being the basis for creative thinking. However, the author sees the potential of language primarily in learning how to plan and overcome impulsive, unstructured activity. On the other hand, as this chapter makes explicit, researchers have since made firm relationships between the use of language for self-expression, spontaneous and humorous discussion – all of which contribute to a playful engagement with work and constitute some of the key factors for creativity to occur (Stables, 2004; Vass, 2002; Issroff and del Soldato, 1996).

Vygotsky's research has influenced most of the work done on collaborative learning. It is also the foundation of the more recent development in educational theory of socially situated learning (Lave and Wenger, 1991(c)), which is discussed in more detail further in this chapter (see section 2.3.3). Researchers in D&T education have been similarly influenced by social and dialectic interactions, particularly as the basis for original thought. Research in D&T in this respect has focussed on exploring the premise of collaborative problem solving as a strategy for creative development. Following are some examples of the findings of such research.

Research on collaborative problem solving as an approach to creative thinking in D&T

One example of how Vygotsky's theory of language as a tool for thinking has been employed is Hamilton's research on the use of dialogue and the application of collaborative problem solving to D&T. He maintains that the nature of D&T as a subject offers an opportunity for students to be active learners:

'...to discuss, to think, to plan, to make decisions, to reflect and apply.'

(Hamilton, 2004: 89)

He identifies collaborative problem solving as a natural approach to learning in D&T. He further places specific emphasis on how teachers make the classroom a place for collaboration amongst learners.

Hamilton identifies that the specific role for teachers within collaborative interactions is to support and encourage pupils with open ended questions, *'which acted as a scaffold in the thinking process.'* (Hamilton, 2004: 91) The author further maintains that it is important for all ideas to be considered, in order to make problem solving a collaborative endeavour - an even chance in the opportunity to speak should be given to all students. This type of management of the learning interactions is one, which would be impossible to achieve without teacher guidance. Hamilton therefore identifies the key role of the teacher in a collaborative problem solving setting as creating opportunities for discussion through *'sensitive intervention and careful scaffolding of student thinking'.* (Hamilton, 2004: 92) This definition for the role of the teacher is similar to the constructivist approach – where the teacher is seen as a facilitator of learning not an instructor who delivers ready made meaning to learners (Doolittle, Camp; 1999).

Once again we are reminded that the role, which the teacher adopts within the learning environment is an essential condition for creativity to develop – a firm emphasis on the teacher as a facilitator of learning is necessary, where the teacher abandons the role of an authority figure. As was previously discussed, both learning with ICT (Loveless, 2002) and the constructivist paradigm (Doolittle, Camp; 1999) ascribe such a role to the teacher, which makes it necessary to consider these as possibilities for creating a learning environment, which supports collaborative problem solving.

A potential role for interactive media can be identified here. As Hamilton's research points out, the primary role of the teacher is that of managing the learning interactions, so that an equal opportunity is given to learners for self-expression. The potential of a learning environment in this case is in structuring the learning interactions in a manner in which one learner's actions depend on those of the other, or where collaboration will explicitly result in a better outcome. Both of these possibilities have been explored in collaborative learning applications, particularly activity theory models in HCI (human computer interactions) research (Kuutti, 2001).

Collaboration: The concept of 'community'

In support of Hamilton's ideas, Head and Dakers similarly start from Lave and Wenger's idea of learning as a social process, where *'knowing is the result of active engagement with the world'* (Head and Dakers, 2005: 36). The authors quote Dewey who sees the classroom as a *'community of enquiry'* where pupils responsible for constructing their own individual understanding can argue out and apply big ideas to real world phenomena.

With relation to the subject of D&T, the authors argue that learning in D&T education requires engagement not only with the made world, but also with the societies and communities which are shaping it. This reinforces the idea of learning in D&T as socially situated collaboration:

'Project based pedagogies allow students to work collaboratively. The nature of the subjects where design and realisation is visible and concrete, enables students and teachers to challenge each others' ideas as their projects develop over time. Working together towards a single collective goal rather than individual projects encourages debate, recognition of particular individual skills.'

(Head and Dakers, 2005: 37).

The authors point out that while the creation of communities of practice can happen naturally their maintenance is a more complex issue - this is largely due to teachers themselves being brought up in the tradition of a *'didactic teaching style'*, which can lead them to bring this experience into teaching and hamper collaboration. From this point of view Head and Dakers describe teachers as often:

'...retreating into cultures of individualism and balkanism'.

(Head and Dakers, 2005: 37)

This view is supported by Prensky's account of the difference between a generation of digital immigrants (the current generation of teachers who have grown up with didactic teaching styles) and the generation of digital natives (the generation of learners who have grown up with computer games and have developed different learning strategies, more attuned to dynamic representation, non linear narrative structures as well as collaboration) (Prensky, 2001: 49). Even though Prensky is referring to the readiness of learners to manipulate and learn with digital media, his message regarding approaches to teaching is identical to Head and Dakers' – new, more interactive approaches to teaching and learning are necessary, of which collaboration is an indelible part.

Head and Dakers propose *'a shift from a ... didactic approach which entails transmission teaching determined by an ethos of control, towards a pedagogy based on dialectical interrogation'* as a first step (Head and Dakers, 2005 : 39).

One condition the authors point out for making this happen is to:

'seek to create the level and type of participation in technology classes in which all parties are accountable to the group in order to foster effective learning in which each member of the group contributes towards the common understanding of the task'.

(Head and Dakers, 2005: 39)

In a sense the authors support a constructivist approach to learning, thus identifying collaboration between students as the key to moving away from didactic approaches to teaching and learning, as is visible from the last two quotations.

As is explored in more detail further in this chapter, it is approaches to theory, which stem from the behaviourist tradition which are more closely associated with a transmission teaching approach (see section 2.3.2). Therefore the emphasis falls once again on an approach based on knowledge construction, supported by a social structure – such as is described by social constructivist learning theory (Doolittle, Camp, 1999; Lave and Wenger, 1991(a); Vygotsky, 1978). The research questions drawn in Chapter 6 are targeted specifically at evaluating principles of social constructivism, applied within an interactive learning environment (section 6.3.1, Structuring learning content and learning interactions). Amongst these are the value of collaborative work, dialogue and experiential learning.

Hennessy and Murphy look at the value of collaboration specifically in the context of D&T. They give the following definition of collaboration:

'pupils actively communicating and working together to produce a single outcome, talking and sharing their cognitive resources to establish joint goals and referents, to make joint decisions, to solve emerging problems, to construct and modify solutions and to evaluate the outcomes through dialogue and action.'

(Hennessy and Murphy, 1999: 1)

It is clear that Hennessy and Murphy's outlook is informed by the sociocultural approach to learning theory, where communication and the social functions of dialogue are central to meaning making. The authors further identify a number of opportunities for learning though collaboration specific to D&T education:

'generate and test out their ideas on each other, decide on a specific task to undertake, consider a design brief, develop product specifications, generate design proposals, choose materials and consider the capacities and limitations of tools and equipment'

(Hennessy and Murphy, 1999: 3)

The authors see the significance of discourse as the following:

'...through discourse design ideas, solutions, plans and decisions are made explicit and visible; discourse also progresses thinking and is central to the process of knowledge construction as ideas are shared and addressed, feedback is received and interpreted, emerging problems are solved and joint decisions are taken.'

(Hennessy and Murphy, 1999: 2)

The authors make a relationship between the capacity of discourse and collaboration for meaning making and relate this directly to the idea of learning as knowledge construction. The constructivist approach to learning theory is once again emphasised, this time directly relating it to D&T.

Multiple forms of representation

Hennessy and Murphy make an interesting point about the relationship between different forms of feedback and different representations. They maintain that the dialogue, which develops amongst D&T learners, is dependent on and influenced by the different forms of feedback, which are available to learners. The authors see different representations (graphical, verbal, physical) as providing *'different forms of feedback or being 'vehicles for collaboration"* (Hennessy and Murphy, 1999 : 4). In these terms we can start to see the relevance of interactive media to learning in D&T. The most powerful aspect of multimedia is that by using multiple forms of media, it is able to combine different forms of representation into one unified environment.

Peer interaction – friendship, humour and spontaneity

Hennessy and Murphy identifying the difference between peer collaboration to teacher to learner interactions:

> *'Compared to working with an adult, students interacting with peers in these studies had many more opportunities to generate and elaborate their own descriptions, and to negotiate shared descriptions.'*
>
> (Hennessy and Murphy, 1999: 12).

The difference in the degree of freedom of expression afforded by peer interaction sets a theme, which this research explores further and which shape an important conclusion regarding creativity. Learner to learner discussion brings in elements of humour and spontaneity, which can only develop amongst peers. This has an impact on the way learners think, allowing for divergent thought to develop, and therefore is more likely to result in creative problem solving, free from extrinsically motivating factors such as have been described to be a hindrance to creativity (Hennessy and Amabile, 1999).

In support of the unique potential which peer collaboration has for creativity Vass identifies humour and spontaneity as some of the characteristic features of such collaboration (Vass, 2002). Vass exemplifies the advantages to learning, which a friendship pair would have as opposed to an acquaintance pair (Vass, 2002). One of these advantages is the possibility for participants to act out and use 'affect-linked thinking' when working with a friend, which would be difficult if working with an acquaintance. Vass demonstrates how acting out and informal discussion between friends, which involves sharing humour and play is beneficial and enhances content generation. From this Vass draws the conclusion that friendship pairs are more likely to benefit from collaboration in the outcomes of their work. Therefore if we accept that collaboration has a positive effect on learning then friendship becomes an optimum condition for learning within a collaborative setting.

2.1.4. Approaches to supporting computer based collaborative learning

Computers add a third dimension to learning dialogues. Cook identifies that providing computer-based learning support that is able to acquire the role of *'teacher as mediator'* (Cook, 2002) is a major area of research.
Cook further explores the question:

'How, or to what extent, can theories and studies of dialogue and interaction be exploited in a concrete way by designers of interactive media for education?'
(Cook, 2002: 1)

Cook maintains that we need to find out more about the mechanisms of the interactions between teacher and students, and that this is an area left largely unexplored.

The author gives as examples projects which have used speech act theory as a way of a computer based system's dialogue planning. Such examples are the AutoTutor system, designed for students on a computer literacy course, and the CIRCLE project, aimed at building dialogic systems (Cook, 2002).
On the basis of empirical work, Cook identifies specific aspects in the design of an interactive learning environment, which can be addressed:

- certain types of learning may not occur unless dialogue takes place between teacher and learner;
- interaction has an adaptive / mediating role helping students resolve and recognise inconsistency;
- explaining one's problem-solving strategy or overhearing the dialogues of others may have a positive impact on learning;

- dialogue may take various forms: disputational, cumulative, exploratory. Exploratory dialogue may be more likely to lead to in-depth learning;
- a 'tentative claim' is made that the reason why some exploratory dialogues may promote cooperative learning is because one of the participants has been prepared to take on the role of a tutor who asks open questions.

(Cook, 2002: 5)

These guidelines imply changes in the roles of teacher and learners in a collaborative learning environment. On the one hand Cook identifies the teacher's intervention as essential for *'certain types of learning'* on the other hand there is the tentative claim that cooperation is enabled by one of the learners adopting the role of the teacher.

A further implication of the guidelines, which reflects on creativity, is the idea that exploratory dialogue is most likely to lead to meaningful learning. The idea of exploratory talk originates from Mercer, who identifies several types of dialogue, which are used in argument – disputational talk, cumulative talk and exploratory talk.

He describes disputational talk as a *'defensive, uncooperative encounter, in which the perspectives of the two participants compete with rather than complement each other'.*

(Mercer, 2000(a): 97)

In cumulative talk *'speakers build on each other's contributions, add information of their own and in a mutually supportive, uncritical way construct together a body of shared knowledge and understanding. '*

(Mercer, 2000(a): 97)

This type of dialogue can be used by people to construct and reinforce, as well as define, the parameters of a shared view.

A third type of dialogue is exploratory:

'Exploratory talk is that in which partners engage critically but constructively with each other's ideas. Relevant information is offered for joint consideration. Proposals may be challenged and counter-challenged, but if so reasons are given and alternatives are offered. Agreement is sought as a basis for joint progress. Knowledge is made publicly accountable and reasoning is visible in the talk.'

(Mercer, 2000(a): 98)

Exploratory talk is the one which seems to have the greatest potential for discovering the new and arriving at innovative solutions. The collaborating learners are not merely accepting and reinforcing a point of view, but are exploring a number of different perspectives in search of the one which seems to offer the best solution. While the criticism of each others' perspectives which exploratory talk inevitably involves can have some negative effects on an insecure learner, all criticism and all attack on a point of view need to be supported by evidence. In these terms if the learners are genuinely driven by the desire to understand and acquire new knowledge reasonably founded criticism would not impede the learning. The aim of the learners should not be to gain control and to assert themselves, but to discover the optimum solution through negotiating the facts. As Mercer says:

'In cumulative talk, participants do not strive for control, while in disputational talk they do. In exploratory talk, control is a matter of constant negotiation, as speakers offer contributions which may, if partners are persuaded, determine the subsequent direction of collective thinking'.

(Mercer, 2000(a): 99)

Mercer argues that no dialogue can be categorised as being distinctly one of these types – dialogue would usually incorporate an amalgam of the three. However within any given dialogue there is the opportunity to find which prevails, and which type most directly influences the outcome of the discussion.

Designing computer supported group based learning

Strijbos et. al. (2004) offer an approach to designing CSGBL (computer-supported group-based learning). The methodology and framework proposed have as their starting point the interactions, which develop in group-based learning. The framework offers a way of expecting these interactions and designing learning material with them in mind. Interactions are thus placed at the core of designing learning material. They conceptualise several aspects of interactions and use these as the basis for a framework for the design of computer supported group learning. The five elements proposed are:

- Learning objective
- Task type
- Level of pre-structuring

Learning objectives

Strijbos, Martens and Jochems (2004) see learning objectives as based either on closed skills or open skills. Closed skills are those which can be learned individually by learners. Open skills – such as argumentation and negotiation are learned best in interaction with others. In open skills the level of interaction is deeper since participants create meaning by building on each other's contributions. The question, which needs to be asked is:

'Do the learning objectives require closed or open skills? '

(Strijbos et. al., 2004: 411)

In the case of this research, where learning is concerned with creativity, we can draw out the learning objectives partly from the indications which research literature on creativity has given. On the one hand there is a need for knowledge and skills identified by the QCA investigation into creativity (Rutland and Barlex, 2002). This would suggest closed skills of learning declarative, factual knowledge. On the other hand however several key sources point to the need for managing uncertainty and risk taking within creative processes (Kimbell, 2000(a); Rutland and Barlex, 2002; NACCCE, 1999), as well as the need for playful engagement and interactions, which predispose towards creative thought (Stables, 2004). All of these strongly suggest the need for the development of social interaction skills and the ability for self-expression, which are indeed open skills. This is an indication that a collaborative learning environment which aims to support learning and creativity needs to include both open and closed skills and will as a result necessarily need to support both individual approaches and collaborative ones. The potential of interactive media to support such flexibility in approaches within a unified environment will be a test of whether computer based learning has the capacity to make a unique contribution to creative learning.

Task type

Strijbos et. al. (2004) draw on educational research to make the distinction between two basic task types in learning – concept learning tasks, which are fact based, and design tasks, which rely on analysis and synthesis. They point out that concept learning tasks are well-structured and require the application of rules and principles with, usually, a single correct solution. In contrast, design tasks are *'ill-structured tasks'*, where the rules and principles are not firmly defined and have no *'clear-cut solution'* (Strijbos, 2004: 411). The latter are more open tasks, which allow freedom for the learner to define goals specific to their own situation. In these terms the authors maintains that well-defined tasks will elicit less interaction since there is only one correct solution, and the scope for discussion and argument is therefore limited. On the contrary, more open design tasks, which naturally require negotiation and interpretation, would entail a deeper level of interaction.

In the case of a learning environment, which aims to support creativity, once again a mixture of task types and therefore – a combination of degrees of structure for each task are likely to be necessary. The need for concrete knowledge and skills in learners, calls for well-structured tasks, which aim to elicit the learning of factual knowledge in the learner. On the other hand the need for generative thought to develop in learners calls for more loosely structured tasks, where the learner is allowed an opportunity for identifying their own goals. Furthermore, such an opportunity afforded by *'ill structured tasks'* has the potential to play a role in building up self-esteem and autonomy in the learner.

Conversational Framework

Laurillard's Conversational Framework is based on earlier theories of Vygotsky regarding learning as a form of dialogue (fig. 5).

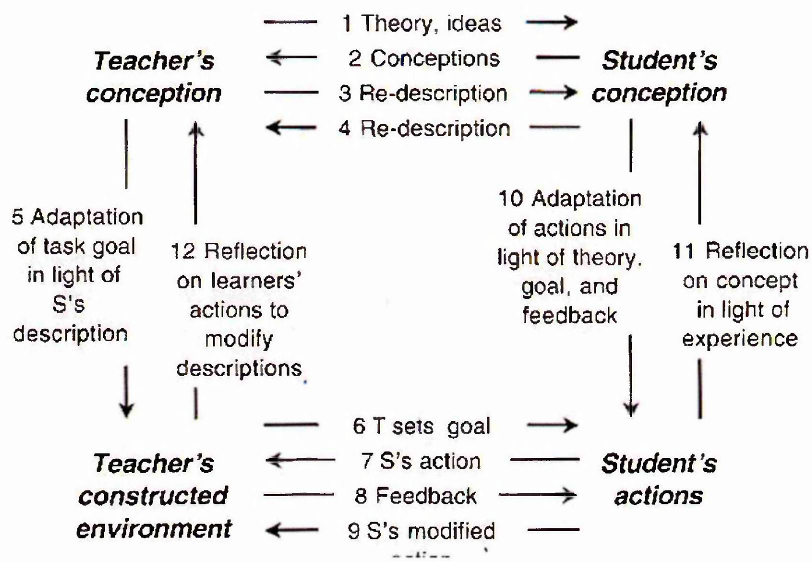

Figure 5 The Conversational Framework, Laurillard, 2002(a) : 87

The key idea of the Conversational Framework is that it sees the ideal learning process as a one-to-one tutorial model. As this form of instruction is difficult to achieve, due to restrictions on teacher time, the Conversational Framework explores the model of the one-to-one tutorial in the context of learning. The significance of the Conversational Framework model is that it makes explicit how these dialogic interactions, which are evident in their application to face-to-face communication between teacher and learner, can be mapped onto dialogic interactions within a multimedia learning environment. Laurillard has identified the types of media which support each of the dialogic forms and functions performed by teacher and learner in the face-to-face model, and has made explicit the way each of these media support learning.

The key descriptors of the Conversational Framework are the following:

- It must operate as an iterative dialogue;
- which must be discursive, adaptive, interactive and reflective;
- and which must operate at the level of descriptions of the topic
- and at the level of actions within related tasks.

(Laurillard, 2002(a): 86)

In emphasising the need for an iterative dialogue, the Conversational Framework places an emphasis on the actors in this dialogue as teacher and learner. Within this the teacher has a central role in providing feedback and more importantly guiding the learning interactions. The teacher identifies any misconceptions of the topic the learner may have through engaging in dialogue with them and on the basis of this knowledge provides guiding feedback. In these terms the role of the teacher as guiding the learning interactions is central to the Conversational Framework.

While such an approach of identifying misconceptions in the learner's knowledge may work successfully in disciplines which require explicit knowledge, its applicability is not as straightforward as for subjects which require creative thinking. As research literature on creativity in an educational context has indicated, the value of learner-to-learner dialogue is unique in this context (Issroff and del Soldato, 1996; Hennessy and Murphy, 1999; Vass, 2002). A shift away from the teacher-led dialogic structure is therefore necessary in the case of learning where creativity is involved.

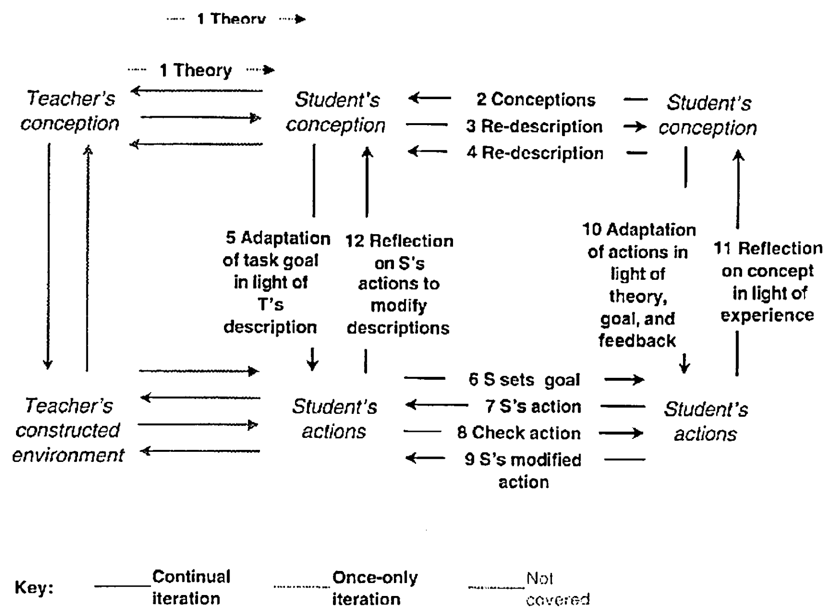

Figure II.2 The Conversational Framework interpreted for learning through lectures.

Figure 6 The Conversational Framework, adapted for learning through lectures. This model takes in partial consideration learner-to-learner dialogue. Laurillard, 2002(a) : 88

In reference to this Laurillard offers an adapted version of the Conversational Framework interpreted for learning through lectures (fig. 6). Yet she does not make a direct reference to the relevance of this approach to creativity. This shapes one of the areas of exploration which the research deals with – what is the optimum role of the teacher within interactions which aim to enhance creativity in the learner and within this what is the value of peer collaboration.

Affective issues in computer supported collaborative learning

Jones and Issroff (2005) point our attention to affective issues in computer supported collaborative learning. The authors start from the viewpoint that such affective factors have a significant bearing on enhancing student learning. From the point of view of this research such an investigation is relevant since as discussed in section 1.2.2, most of the factors of creativity are affective. The following factors are identified by Jones and Issroff as having an impact on the affective layer of learning:

- The issue of control is given the greatest emphasis as a motivational factor. Within the context of an Interactive Media Learning Environment (IMLE) this issue is related to the degree of control the learner has over the system and the amount of guidance, which needs to be given within the interaction. The author points out that having control over a system and being able to choose the paths of interaction is a strong motivational factor for the learner.

- A desired effect of learner control is users having 'ownership of the learning problem'. This is seen as a highly motivating factor. A similar notion is inherent to the situated approach to learning (Lave & Wenger) – which maintains that the learner relates what they are learning to the social world, and to the outcomes, which they pursue in learning. This is also supported by Laurillard who maintains the importance of the learners discovering individual meaning in the learning, and being able to carry knowledge into the context of their own work (Laurillard, 2002(e): 11).

- Social affinity between learning partners has a positive effect on learning. One of the explanations of why this happens is that students who are used to working with one another have already established ways of working together and ways of negotiating goals. These are factors, which encourage the construction of meaning, knowledge and understanding in dialogue.

As this thesis explores further these affective factors do prove significant to learning. However there is no direct relationship established with creativity, or the subject of D&T. The contribution, which this research makes to the exploration of affective factors by Jones and Issroff, is in the use of such factors to promote creativity within an IMLE specifically aimed at D&T learners.

2.2. Game-based learning – a form of non-authoritarian, stimulating learning environment

2.2.1. Game-based learning and learner autonomy

The literature reviewed has shown a direct relationship between the need for risk taking and creative development (Rutland and Barlex, 2002; Kimbell, 2000(a)). A number of references point to the capacity of games to provide an environment, which is free of risk, and where users can uninhibitedly explore scenarios which would generally be unavailable or risky in a real world situation. In his discussion of games and simulations as learning environments Adams pinpoints their benefit not only to risk taking but also to learner motivation:

'Games are often heuristic rather than didactic and therefore less authoritarian, making people feel more comfortable; they can attempt new activities without fear of censure.'

(Adams, 1973: 9)

The characteristics of an environment, which predisposes learners towards creativity involve:

- a discovery approach to learning;
- the ability to act free of censure, and free of the influence of authority;

The idea of exploration and discovery as the natural strategy towards creative problem solving has been identified by Csikszentmihalyi (1996(a)), and is further implicit in the constructivist approach to learning environment design (Boyle, 1997(a)).

Further, the idea that the lack of an authority figure can put the learner at ease and allow them to think more freely, is supported by Hennessey and Amabile (1988: 33), as discussed in section 1.2.2.

We can therefore see the positive impact, which a game-based learning environment can have on enhancing creativity in the learner, and are further able to summarise its characteristics as discovery based and non- authoritarian. Moreover a relationship is evident between games as an approach to learning and the constructivist paradigm – namely – moving away from instruction and into learner-led, autonomous exploration:

'the key difference between simulations and traditional methods of learning is the emphasis on experiencing as opposed to simply being taught'
(Adams, 1973: 9)

Games are therefore seen not only as non-authoritarian but also as active and promoting autonomy in the learner. In support of this, Dondi, Edvinsson and Moretti (2004) make explicit the benefits of non-formal learning as can be found in games to promoting learners' autonomy, independence and personal development. The authors attend to the fact that formal learning takes place within an institution, is structured and accredited. In contrast, non-formal learning takes place within a mainstream educational structure but is not accredited. Further, informal learning is not necessarily intentional or structured. As a reason why society should be interested in informal learning, Dondi et. al. identify that non-formal learning does not aim to control learning or judge the process. In this way it allows for a greater freedom in learning – decision-making is in and of the learner and the motivation to learn is intrinsic. Thus the learner has a greater chance to develop individualism and autonomy (Dondi et al., 2004).

The identified relationship between active, constructivist, discovery-oriented approaches to learning with game-based environments, is further supported by Prensky (2001). Prensky identifies discovery and exploration as an attribute and a natural learning style for the entire generation of learners who are growing up today, under the influence of computer games. He defines these as the games generation, or *'digital natives'* (Prensky, 2001: 35).

The author maintains that a key characteristic of the so called games generation, who use and have grown up with interactive media, is that they are accustomed to discovery approaches to learning and active participation such as make up the structure of computer games. This generation are not used to linear exposition and passive observation is boring for them.
This inclination of the games generation to discovery orientated approaches to learning and active participation makes constructivist approaches to learning

theory much more appropriate and responsive to their learning needs (Prensky, 2001: 49).

It becomes evident therefore that the challenge for e-learning and computer based learning is partly in providing teachers with the tools for delivering learning in an interactive way. This reinforces the ideas explored in section 1.1.1. The need for a framework or structure for teachers to utilise is relevant as providing a starting point on which teachers can build and add to, thus reducing the effort for teachers to invent discovery oriented approaches to learning but rather encouraging them to contribute to such resources with content and suggestions for pedagogy.

2.2.2. Game-based learning – an immersive, motivating environment

A further element contributing to pedagogy begins to emerge as inherent to GBL (Game-based learning) – this is the element of motivation. The dynamic forms of representation which digital media provide and to which *'digital native'* learners seem so responsive, owe their pedagogical potential to the motivation and ability to engage the learner in deeper exploration of the subject.

Prensky identifies the potential of games to create an immersive experience. Such an experience is valuable since it enhances the 'flow' state – a state of increased involvement, which was identified by Csikszentmihalyi to be essential to creativity (Csikszentmihalyi, 1996(b)). An immersive experience is also related to an increased intrinsic motivation in the learner, which as identified by Hennessey and Amabile occurs as a result of enjoyment and pleasure, and is also one of the major factors for creativity to develop.

The 12 elements identified as motivating by Becta (fig. 7) correspond very closely with Csikszentmihalyi's 9 elements describing the experience of flow – characteristic of creative activities:

- *There are clear goals every step of the way*
- *There is immediate feedback on one's actions*
- *There is a balance between challenges and skills*
- *Action and awareness are merged*
- *Distractions are excluded from consciousness*

- *There is no worry of failure*
- *Self-consciousness disappears*
- *The sense of time becomes distorted*

(Csikszentmihalyi, 1996(b): 111)

Since there is a close correspondence between the identified characteristics for motivation in computer games and creative flow, game-based activities can be seen as a possible way of providing the conditions for creative learning, if used appropriately. Research by Becta (2001) looks further into the educational potential of the type of motivation, which can have an impact on pedagogy:

Motivation (from Becta 2001, page 2)

What indicates motivation?	Independent work Self-directed problem posing Persistence Pleasure in learning
What generates motivation?	Active participation Intrinsic and prompt feedback Challenging but achievable goals A mix of uncertainty and open-endedness
What can motivation usefully support?	Collaborative interaction Peer scaffolding of learning Creative competition or cooperation Equal opportunities
What does sustained motivation rely on?	A version of reality Relevance to the user Recognisable and desirable roles for players
What are the problems with motivation?	Motivation may lead to obsession Motivation may cause transfer of fantasy into reality Motivation may induce egotism

Figure 7 The elements of motivation, Becta, 2001

Shneiderman supports this view further maintaining that the most significant advantage of using the game-like experience in learning is the increased level of motivation to the learner. He uses Nelson's *'principle of virtuality – a representation of reality that can be manipulated'* (Shneiderman, 1998 : 202), maintaining that the principle of virtuality, applied within direct manipulation, is linked to *'user excitement'*.

There is scope for argument therefore that if the effect of user excitement is present, this indicates that users are displaying a certain degree of intrinsic motivation which in research literature has been identified as an important condition for creative thought to develop (Hennessey and Amabile, 1988 : 17). We can infer that there is a link between a game like setting, which gives pleasure to the learner, and creative thought (fig. 8).

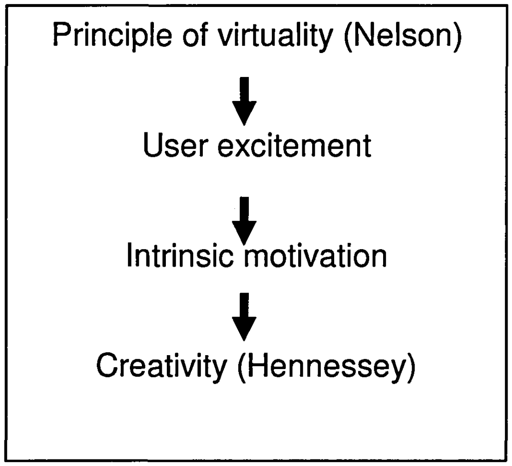

Figure 8 The relationship between direct manipulation and creativity

The research questions drawn out in Chapter 6 are aimed at exploring this relationship between the form of interaction – direct manipulation and its effect on learner motivation and creativity (section 6.3.1., Structuring the learning interactions – interface design which supports learning and creativity).

2.2.3. Game-based learning and problem solving

Other than motivation, a further advantage of the games set up is that it readily lends itself to active, problem-solving, constructivist learning. As this research will make explicit through empirical data, as well as on the basis of research literature, such problem-solving and active learning is the natural approach, which D&T students are used to adopting.

Game based learning needs to be active and constructivist in nature, in order to sustain the element of motivation in the learner (Oxland, 2004 : 24). Dondi et. al. describe the game environment as *'active and integrated'* (Dondi et al., 2004

: 36). The learner is acting within a performative environment, where activities such as discovery, exploration, problem-solving, memory use, analysis and interpretation are encouraged and naturally take place. Such activities are characteristic to the constructivist paradigm. Prensky goes further to make a relationship between the problem-solving side of game-based learning and creativity. In his list of reasons why games engage learners Prensky points out:

'Games have problem solving. That sparks our creativity.'

(Prensky, 2001 : 34)

2.2.4. Game-based learning as socially situated

One of the basic challenges to a creative and cultural education especially where technology is involved, is to provide opportunities for social and collaborative learning (Csikszentmihalyi, 1996; NACCCE, 1999; Hennessy and Murphy, 1999; Vass, 2002; Hamilton, 2004). Game-based learning was discussed as having potential both in terms of the necessary stimulus it provides to learners in the level of motivation it offers, as well as in terms of its implicit active model of engagement, which emphasises a constructivist paradigm. The question is - does game-based learning rise to the challenge for education to be collaborative and socially situated?

Kirriemuir and McFarlane emphasise that the primary use of computer games is in the opportunity they provide for active participation within a social world:

'Contrary to populist media opinion, games are often a facilitator to social, communication and peer activities... An early study...argued that half of all young people who spent time in video games arcades weren't actually playing games at all – rather they were using the arcade as a social gathering place.'

(Kirriemuir and McFarlane, 2004 : 14)

The Becta games in education project similarly reported findings relating to the value of games as a collaborative activity (Becta, 2001). Games were reported to stimulate discussion and collaboration between learners. This is seen as related to students' development of awareness of the wider context of the subject explored. For example the Sims games were reported to inspire discussion on themes such as alternative energy sources, pollution, citizenship.

Real time strategy games had an impact on students' awareness of the significance of collaboration and team-work. It was reported that students soon realised that decisions, which resulted from discussion with each other were more effective and well considered than those, which were made individually.

Collaboration was also reported to have impacted on the students' social awareness and skills. Students realised *'the rewards of helping others achieve'* (Becta, 2001 : 9). This also had the added benefit on students who helped others in helping them build their self-esteem through the feeling of responsibility they took for others.

2.2.5. Summary

The potential benefits of game-based learning to creativity can be summarised as:

- A non-authoritarian learning environment, which encourages learners to act free of censure and in this way be able to express themselves freely and creatively.
- The opportunity for autonomous learning provided;
- An immersive, motivating environment;
- Opportunities for active constructivist problem solving;
- A social, collaborative structure for learning interactions which may help develop valuable social skills such as communication and promotes learners' self-esteem;

Each of these points were discussed as being characteristic of the constructivist paradigm and discovery based approaches to learning, while at the same time being related to the findings of the literature review as conditions for creative development. This necessitates a closer look at the constructivist paradigm and its varieties in order to establish its relevance to the study. The following section discusses in detail key approaches to learning theory from the point of view of their relevance to enhancing creativity.

2.3. Learning theory

2.3.1. Introduction

The literature review shows that the following aspects of learning theory are most important when considering creativity:

- the need for supporting reflective as well as generative thought;
- the need for a knowledge and skills basis;
- the need for active engagement on the side of the learner;
- capacity to construct knowledge based on personal and collective experience;
- the need for collaborative problem solving;
- a strong stimulus and is characterised by a deep level of engagement on the side of the learner.

While most of these elements are characteristic of the theoretical model of constructivism, the need to provide knowledge and skills necessitates an exploration of instructional approaches to theory as well. Further, constructivism can be approached in different ways. This section examines the relevance of a variety of approaches to learning theory in order to find the optimum approach to enhancing creativity.

2.3.2. Gagne's conditions of learning

The need for a firm skills and knowledge base was expressed as one of the key conditions of creativity (see fig. 1). It is this need that makes it necessary to look in more depth into the behaviourist tradition and instructional design.

Instructional design originates in Gagne's *Systems approach* - a useful framework for the design of instructional material (Gagne, 1985(c) : 21). This involves the mapping of target objectives (what we want students to learn) onto performance objectives (what actions on the part of students will demonstrate that they have learned). Gagne developed his taxonomies of learning comprised of five categories:

- verbal information
- intellectual skill

- cognitive strategy
- attitude
- motor skill

While it covers all areas of learning, this theory is only developed to the extent of identifying the conditions of learning and instructional events as regards intellectual skills. Yet, as this literature review has identified, where creativity is concerned learning is closely associated with developing a change in the learner's attitude. However, while Gagne's theory is detailed in its treatment of intellectual skills, where the category of attitude is concerned, a systematic approach or description of the conditions of learning is missing.

Firstly, while Gagne recognises the value of social interaction and collaboration as having a key importance in attitude change, he does not define in detail the pedagogy or design principles where this change in attitude happens as part of group interactions. General aspects are identified - such as contingencies of reinforcement, demonstration of attitude etc, however these remain vague and general with no supporting teaching strategy or pedagogical approach. Furthermore, Gagne's theory of instructional design fails to consider dialogue and social interaction as valuable factors in learning.

In Gagne's theory of instruction learning is always centralised – a figure of authority – usually a teacher – imparts instruction to learners: In these terms the roles of teacher and learner are constant and static in the way they relate to each other. As will be discussed in section 2.3.3, Lave and Wenger's theory of situated learning offers a different outlook on the situation. According to them learning is a matter of 'legitimate peripheral participation', where the learner moves from the periphery towards the centre of the learning setting. Thus the roles of learner and teacher are in constant flux with each other, being continuously renegotiated. In these terms, there is movement in Lave's theory, which takes into account progress and development in learning. A similar notion is expressed by Vygotsky in his zone of proximal development. These aspects are absent in Gagne's theory of instructional design, where the teacher- learner hierarchy remains unquestioned and to a large extent unexplored.

Motivation

In the external factors of learning Gagne includes that of motivation. According to him, learner motivation can be enhanced if the learner is able to expect *'the nature of the achievement'* and the outcomes of learning (Gagne, 1985(c) : 303). The importance of learning goals being made evident to the learner is also supported in the research literature on game-based learning (Prensky, 2001; Becta, 2005; Shneiderman, 1998). In discussing narrative structure Laurillard and Plowman et. al. identify that being aware of the goals of learning at all time is an essential condition for meaning making (Plowman et. al. 1999; Laurillard, 2002).

One key difference between these approaches and Gagne's thinking however, is that Gagne sees the clarification of the goals of learning as something which the teacher communicates to the learner. This runs contrary to the identified need for enhancing autonomy and giving opportunities for self-expression to the learner (Rutland and Barlex, 2002; Hennessy and Murphy, 1999). Learners are expected to take learning into their own hands and identify their own projects to work on – which is the equivalent to identifying their own goals of learning. In these terms the goals of instruction cannot be fully defined. The goals of instruction are to encourage the learner to identify their own goals in learning. In these terms Gagne's principle of *'informing the learner of the objective'* is too limiting and runs contrary to building learner autonomy. Rather an approach closer to aiding the learner in identifying their own goals would be closer to the ethos of creativity.

Providing learning guidance

For the stage of providing learning guidance Gagne proposes that verbal questioning should be used to 'channel' the learner's thinking. He also proposes techniques such as:

- Suggesting the answer required;
- Learning guidance through prompting;

(Gagne, 1985(c) : 312)

The implication of these techniques is that a predefined right or wrong answer exists and the teacher's role is defined as guiding the learner through prompting and suggestion to the only possible right answer. While this type of instruction works for acquiring explicit knowledge, it runs contrary to the nature of divergent, creative thinking. If the aim is to encourage students to find their own original solutions to design problems, then providing guidance through suggesting the right answer is largely ineffective. Yet, it needs to be considered that in reality thinking creatively about a subject needs to be supported with explicit knowledge on the subject. It is in this circumstance that Gagne's approach remains valuable and an indelible part of a learning environment, as will become clear in Chapter 6.

Feedback

According to Gagne one of the primary uses of feedback is to reinforce 'correctness' of the learner's actions and further - to reflect *'the degree of correctness of [learners'] performance'* (Gagne, 1985(c) : 314)
He discusses the use of feedback from the point of view of giving encouragement for newly learned skills. He also proposes the use of feedback as a way of letting the learner know what is right and wrong. This kind of treatment of feedback is undoubtedly relevant where the acquisition of explicit knowledge is concerned. However, once again it reflects a system of imparting instructions to the learner in a centralised hierarchical organisation – from teacher to learner. Gagne fails to consider other forms of feedback, characteristic of learning through social interaction – such as the feedback, which learners give to each other within a group-learning situation. Such feedback does not have to be necessarily 'right' or 'wrong' – but rather a different perspective, and a different way of thinking, as in brainstorming ideas for projects, which is an established practice in teaching / learning the subject of D&T.

Summary of section

While Gagne's approach comes close to providing a system for deriving an instructional system, based on the goal of instruction, this approach fails to consider some of the essential elements of creativity identified in this chapter:

- The social dimension as a condition of learning is omitted and a heavy emphasis is placed on teacher to learner interactions. Within this the interactions between peers remain largely unacknowledged and marginalized;

- Gagne's approach to the design of instruction is centralised, as opposed to the more flexible structure provided by Lave and Wenger's situated learning where the roles of teacher and learner are subject to continuous change;

Despite of these drawbacks, Gagne's *systems approach* is useful in considering the design of instruction where declarative knowledge and intellectual skills are concerned.

The following sections look more closely at the constructivist paradigm and its varieties as providing a viable supplement to the instructional approach, and more adequately addressing learning needs where creativity is concerned.

2.3.3. Constructivism

As an approach to learning theory, constructivism refers to the idea that knowledge is not a given but is rather constructed by the individual. Constructivism is based on the following epistemological tenets:

- Knowledge is not passively accumulated, but rather, is the result of active cognising by the individual;
- Cognition is an adaptive process that functions to make an individual's behaviour more viable given a particular environment;
- Cognition organizes and makes sense of one's experience, and is not a process to render an accurate representation of reality;
- Knowing has roots both in biological/ neurological construction, and in social, cultural and language-based interactions.

(Doolittle, Camp, 1999)

Constructivist pedagogy is based on the following principles:

1. Learning should take place in authentic and real-world environments;
2. Learning should involve social negotiation and mediation;
3. Content and skills should be made relevant to the learner;
4. Content and skills should be understood within the framework of the learner's prior knowledge;
5. Students should be assessed formatively, serving to inform future learning experiences;
6. Students should be encouraged to become self-regulatory, self-mediated, and self-aware;
7. Teachers serve primarily as guides and facilitators of learning, not instructors;
8. Teachers should provide for and encourage multiple perspectives and representations of content.

(Doolittle, Camp, 1999)

The tenets of constructivism act as general guidelines for the design of learning environments. It is evident however, that different approaches have evolved emphasising specific aspects of constructivism. This section will explore two of the main variations of constructivism – cognitive and socio cultural – which bear direct relevance to the goals of the research.

Cognitive constructivism

Cognitive constructivism emphasises the processes of the learner internalising knowledge. The goal of education from the point of view of cognitive constructivism is the creation of a rich sets of cognitive tools to enable the learner to explore and interact with the environment. It is closely associated with Piaget's theory of cognitive development (Piaget, 1971, Biology and knowledge). Other proponents are Jerome Bruner (1966) and Seymour Papert (1980).

In his book Mindstorms (1980(b)), Papert proposes that a computer microworld can provide learners with an environment where they can have a direct experience of Newtonian laws of motion, and acquire the necessary intuition about the subject. What Papert puts forward is a contextually rich environment where experiential learning can take place. He defines three design criteria for the construction of microworlds:

- learning should start with a simple example of the law of motion to be studied; this example is usually delivered through simulation;
- learners should be allowed to manipulate the ideas through the use of games, play, art etc., which would give a purpose for the practical application of an abstract concept;
- all concepts used should be defined and explained within the microworld. This would ensure that he learner is equipped with the necessary knowledge and skills to manipulate the concepts.

Papert develops further the idea of pleasure through discovery, drawing our attention to the element of control. According to Papert a child feels empowered when they master the principle and see its effect on screen. Similar notions are expressed by Shneiderman who speaks of the pleasure of achieving mastery, and proposes that as the main stimulating factor in playing computer games (Shneiderman, 1998). The issue of control is seen as a major factor for meaningful learning interactions by Boyle who maintains that if the user is not in control of the system, they will be unable to learn (Boyle, 1997(a)). Thus the learner will be stimulated and will feel empowered when in control of the learning environment.

The claim that discovery is pleasurable and stimulating leads us to consider discovery as an approach to learning which is appropriate when we speak of encouraging creativity in learning, since stimulus and enjoyment were already discussed as a major factors for creativity to develop in the learner (Hennessy and Murphy, 1999; Rutland and Barlex, 2002; Cropley, 2001; Becta, 2001; Prensky, 2001; Shneiderman, 1998).

The emphasis of the idea of microworlds on experiential learning relates to the fourth constructivist principle - content and skills should be understood within the framework of the learner's prior knowledge.

Situated learning

Papert maintains that in learning a theorem what is important is not to memorise it but to see how it can be used as a tool for thinking in a variety of contexts.

Concepts ought to be transferable. Laurillard takes this idea further by proposing that it is necessary for learning to progress from learning concrete examples to the learning of abstract ideas and thus situating learning.

However, this aspect of situating learning in the context of a system of ideas does not carry further with Papert to situating learning within a social context. The collaborative aspect of learning is not sufficiently emphasised by Papert, even though examples of his own empirical work are always socially situated. Further, while Papert defines some key principles of how a learning environment can aid the construction of knowledge through supporting discovery and exploration, he does not specify or discuss meaningfully the role of the teacher in the human computer interaction and the learning setting. His analysis is limited to the computer and the child, but even though it mentions the teacher's open ended questions as facilitating the enquiry he never goes further into specifying to what extent this guidance should be detailed, in what circumstances it should be given.

From the perspective of developing ways of thinking and cognitive skills in the learner, cognitive constructivism is an appropriate choice of theory. However if looking at it from the perspective of generative thought and creativity, as well as reflective thought in a sense of looking for original problem solutions, it is apparent that what has come to be know as the socially situated character of learning (Lave and Wenger, 1991(c); Laurillard, 2002(c)) is missing within cognitive constructivism. A microworld is a closed entity within which the learner remains essentially alone, and is not open to socially situating their learning. As a result activities such as idea exchange and meaning sharing are not supported. As the literature review on creativity already discussed (section 2.1.3), such activities are central where the object of learning is finding new meaning, and developing original thought.

While the potential for learning in a cognitive constructivist model is undisputed, it is limited in its capacity to address the need for originality and creativity in the learner. This brings us to consider another form of constructivism, which takes into account the social, situated character of learning – social constructivism and the idea of situated learning.

Social constructivism

The strand of constructivist learning theory, which places a greater emphasis on dialogue and social interactions as a support structure for the development of thought is social constructivism. The key proponent of social constructivism is Lev Vygotsky. Vygotsky's ideas about the significance for language as a thinking tool were already discussed in section 2.1.3. Vygotsky's theory shows a close relationship to the use of language as a strategy for problem solving. This reinforces the value of language as a learning strategy, specifically to D&T, where problem solving is often utilised.

Vygotsky goes further than merely identifying language as a learning strategy – he proposes a theory, which looks at learning as a developmental process, and explains the role of language within this.

Vygotsky is the first to notice that the actual development of the individual is different from the potential for future development, which the individual is capable of displaying. This potential he terms the zone of proximal development (Vygotsky, 1978(b): 84). The zone of proximal development – problems, which the child can resolve through collaboration but not on their own, is defined as:

'functions, which are not developed but are in the process of maturation.' (Vygotsky, 1978(b): 86)

Vygotsky claims that these functions are more indicative of the process of development than the child's actual level of development.

What is significant about the theory of the zone of proximal development, is that Vygotsky proposes that it is in collaboration and dialogue and guidance from teacher and peers that the functions of the zone of proximal development can become active, and potential development can become actual ability. Vygotsky's theory is therefore aligned with the idea of learning and development being necessarily socially situated.

Vygotsky's ideas have become the grounding for the constructivist principle that learning should involve social negotiation and mediation. Their relevance to this research and to creativity is apparent and implicit as the review of literature has shown (see section 2.1.3).

Lave and Wenger go further to propose a view on how such collaboration and support function and develop within a learning setting. Their outlook on learning and development is grounded in and builds directly on Vygotsky's ideas.

Situating learning in communities of practice

Building on Vygotsky's ideas, in their theory of situated learning, Lave and Wenger see learning as a matter of participation in communities of practice. In acknowledging the significance of the social environment, and in seeing learning as situated within a social world, Lave and Wenger's theory is closely related and a direct descendant of social constructivist approaches to learning. There is however a significant difference between the situated learning approach and constructivism, expressed by the authors as the idea of legitimate peripheral participation (Lave and Wenger, 1991 (d)).

Internalisation and legitimate peripheral participation

The constructivist view of learning is that knowledge needs to be internalised by the individual for learning to occur (Doolittle, Camp, 1999; Vygotsky, 1978(a)). Accordingly research into learning focuses on how to facilitate this process of internalisation. Lave and Wenger place the focus elsewhere. They are interested in the changing relations within a community of practice. Their concern therefore is with the conflicts, which develop in social practice. Learning is seen not as a single act of internalisation but as *'trajectories of participation'* (Lave and Wenger, 1991 (d) : 89). Progress in learning is evaluated with the changing roles, which the individual acquires within the learning process.

In legitimate participation therefore there is no clear teacher – learner dyad. This type of approach could be difficult to implement in schools, where the teacher has a firmly established role. However it is worthwhile to consider that within the national curriculum A level is a time where students need to be encouraged to take control over their work. Particularly in the context of creativity in D&T, self-directed learning is encouraged, where the student is expected to take a firm step towards asserting their autonomy (Rutland and Barlex, 2002; Hennessey and Amabile, 1988). Taking such a step is similar to the idea of the changing trajectories of participation, where the teacher's role becomes less well defined and diminishes in its instructional character to give way to the learner's personal development as self-directed. The teacher-learner relationship is not as well defined as it would be at earlier stages of development such as KS2 or KS3 for example. The theory of legitimate participation is more than relevant in a school setting, where changing trajectories of learning are identifiable in students' development as independent learners and where the teacher's role is becoming less relevant as that of an instructor.

As was already discussed, the changing emphasis in the roles of teacher and learner and the increased focus on self-directed learning opens possibilities for computer-based learning. As was discussed in section 2.2, the digital medium provides a form of non-authoritarian learning environment within which the learner can act without fear of censure and develop their autonomy. Lave and Wenger's idea of trajectories of learning where the teacher to learner relationship is seen as evolving, accommodates and welcomes the notion of self-directed learning, as well as the role of computer-based learning within this.

Further, the notion of the learner's role within the learning setting being in constant change and becoming 'decentralised', as well as the idea of legitimate peripherality – which suggests a varying degree of responsibility and participation for each learner – necessitate a different medium to the highly structured and linear mode of learning adopted in traditional classroom settings. As was previously discussed in section 2.1.2, digital media are versatile in terms of the degree of control they can offer to the learner, as well as the amount of guidance and feedback provided (Laurillard, 1998; Plowman, 1999). Thus interactivity can provide the necessary flexibility of the learning interactions which learners can use to tailor or orchestrate (Gee, 2003) their own learning experience depending on their level of development and current degree of understanding and participation in the learning setting. In these terms digital media offer unique opportunities for supporting Lave and Wenger's approach of situating learning within a social world and affording varying and evolving degrees of participation to the individual learner.

Situated learning and problem solving

Problem solving is inherent in the situated learning approach. Lave and Wenger express this as learning being situated in the authentic activities of the subject setting (1991(c)).

Lave and Wenger's idea that knowledge can never be completely internalised, in the way constructivism proposes, carries with it the implication that knowledge and meaning are not a constant in the learner's world. Rather, there is a continuous negotiation and renegotiation of meaning. Understanding and experience are in constant interaction, defining and redefining each other. This way of seeing knowledge as an evolving entity, allows for the dichotomies between *'thinking and acting in the world, between contemplation and involvement, between abstraction and experience'* to be dissolved (Lave and Wenger, 1991(c) : 45). This leads us to one of the main tenets of situated learning – that abstract knowledge without practice is irrelevant. Indeed practice furthers our understanding of theory and theory defines what we do in practice. Situated learning purports that the two do not exist in isolation where learning is to occur. Thus situated learning bears a relationship to active, dialogue-based problem solving, which in turn can be related to the inherently problem solving, social nature of practices in D&T (Hennessy and Murphy, 1999; Hamilton, 2004; Head and Dakers, 2005).

Situating learning in context

The theory of situated learning argues that the learner's knowledge should always be situated within a domain specific context. Thus situated learning is opposed to the de-contextualisation of knowledge through teaching abstractions, such as may appear in some forms of academic teaching. Laurillard expresses this in the following way:

'We have to help students not only to perform the procedure, but also to stand back from it and see why it is necessary'

(Laurillard, 2002(d) : 15)

The danger of teaching abstract concepts is seen in the learner being able to perform certain activities involving knowledge of the concept but at the same time being unable to transfer this to real life situations and to use this knowledge within their work. This danger of losing sight of the objective through teaching abstract concepts is also what the technological challenge described in the report *All Our Futures* argues should be addressed, in proffering that all forms of creativity should not be used as an end in themselves but as a tool for contributing to a better way of living and a better future (see section 1.1.1). The argument for situated learning in this respect is that students should be able to:

'...use knowledge in authentic activity, i.e. genuine application of the knowledge'

(Laurillard, 2002(d) : 14).

This applies especially to a subject such as D&T, which essentially looks at the design of objects, which meet particular, very specific user needs. While situated learning deals with specific contexts, abstraction is generally associated with an academic or theoretical type of knowledge.

Summary of situated learning

To summarise, situated learning contributes to this research with several valuable aspects of learning theory, which need to be considered as guidelines in the design of learning materials:

- There is a need to situate learning within a social context, and further – within a community of practice. This takes into consideration the evolving relationships amongst learners and this with a teacher;

- Learning is decentralised, where the teacher-learner dyad is not anymore a static entity but one experiencing continuous change, as the learner's understanding and abilities within the learning domain improve. Interactive media and computer-based learning have this capacity for being flexible and diverse enough to be able to accommodate learners at different stages of development and therefore to address the individual learning needs of each student more adequately.

- Learning needs to be situated within the authentic activities of the subject setting. This creates a relationship with approaches such as collaborative and problem-based learning, which have been identified to naturally correspond to the nature of D&T as a subject domain.

2.4. Summary of chapter

This second chapter of the literature review has explored the capacity of interactive media to address relevant content provision through interactive narrative structures, support risk taking and manage learner autonomy through the use of collaboration and social interaction and provide the necessary stimulus to the learner through implementing elements of direct manipulation and immersive engagement such as are characteristic of game-based learning.

As a result the need for collaboration and the social constructivist perspective have emerged as the optimum approach for the design of learning, where creativity stands as the learning objective. This has an impact on the pedagogical grounding in learning theory which interactive media adopts. Approaches of social and cognitive constructivism were discussed, as well as more recent developments of situated learning. The behaviourist approach was compared to the highlighted issues grounded in the constructivist approach, discussing the benefits and shortcomings, which Gagne's systems approach offers to the design of learning materials. A strong sense of the useful aspects of a combination of approaches has started to emerge. Such aspects are the notion of decentralising learning hierarchies implicated in situated learning, the need to use language as a tool for thinking within a collaborative learning structure, the importance of factors such as feedback, control and setting of goals where appropriate.

Chapter 3. Epistemology and Theoretical Perspective

3.1. Introduction

This chapter summarises the issues the research addresses, derived from the contextual review in Chapters 1 and 2. A synthesis of epistemological positions follows, drawing out the optimum approach before discussing theoretical approaches and judging the appropriateness of these against both the research aims and the epistemology adopted.

The chapter further examines the links between epistemology, methodology and specific research methods.

3.2. The aims and objectives of research – an impact on epistemology

The contextual review of the relationship between creativity, learning technology and D&T education points to social interaction and collaboration as essential elements in a well-balanced learning context. The technological challenge outlined in the All Our Futures report (NACCCE, 1999), expresses a concern for the social and personal development of young people who deny themselves the necessary degree of social interaction through excessive use of technology. This concern makes it explicit that whenever computer based learning is discussed in an educational context, the fear of it substituting human-to-human social interactions is also present. This is one reason why a study of the relevance and value of computer based learning needs to have a firm focus on social interactions.

This chapter further examines the role of the teacher in a computer assisted learning environment. The most successful identifiable view of how this role can be resolved is as that of a learning facilitator (Doolittle, Camp, 1999; Mercer, 2000(b) : 161). Resolving the respective roles of learner computer and teacher has its answer in the interactions between people, the dialogue, which develops amongst them. The role of research is therefore to establish the way these interactions can be enhanced in order to make optimum use of new technology but at the same time not to compromise what is precious and valuable in human contact.

The contextual review further directs our attention to learner autonomy, self-esteem and students' ability for self-management. In identifying the key factors necessary for creativity to develop in the D&T classroom, the Nuffield QCA Project's investigation into creativity (Nuffield QCA Creativity Research Project) states that it is when students are placed in the position of having to autonomously select and generate ideas and write their own briefs, as well as bring these to a successful conclusion, that they struggle the most. (Rutland and Barlex, 2002). Attitude change is brought to the forefront by this concern with learner autonomy. Research which aims to gain an understanding of the affective layer of learning needs to be concerned with the way in which the individual creates meaning in the world, the way this meaning is negotiated, asserted, or rejected, the structures which govern the way such meaning is constructed.

So the choice of an epistemological approach with its consequent theoretical perspective has to allow for opportunities for dealing with the affective layer of learning and meaning making; has to be able to address factors in the emotional as well as the intellectual development of the individual; has to be sensitive enough to allow for the complexity of the data generated to be captured thoroughly and holistically.

3.3. Epistemology

The epistemological traditions, from which educational research derives its methodologies, can be defined in two most broad categories – objectivism and constructivism (Crotty, 1998(a) : 5). In basic terms, the dualism between these epistemologies originates from how they see the world – where objectivism relies on the idea of truth and knowledge as a given in nature. The role of the objectivist thinker, researcher, or scientist is therefore to discover this already existing truth through methods of deductive reasoning (Cohen et. al. 2000 : 4).

Constructivism on the other hand, has evolved with the challenge to deductive and purely theoretical reasoning, resting exclusively on logical thinking, not on experiment. Constructivism maintains that truth and meaning are inseparable from the individual who experiences in the world. In this way the individual is seen as co-producing meaning through actively engaging with the world, involving both their senses and their reasoning in the process (Howe, Berv, 2000).

Essentially, objectivism believes in discovering the truth, which exists as a ready made entity in the world, whereas constructivism sees meaning and truth as created or constructed by the individual. Consequently objectivism relies on quantitative methods, and trying to know the world as a given, while constructivism utilises qualitative methods and tries to understand how meaning and truth are constructed in the world through the active engagement of the individual with their environment.

The next section explores both epistemological traditions in relation to the research aims.

3.4. Theoretical perspective

According to Crotty, (Crotty, 1998(a) : 4) - a theoretical approach has implications for the methodology to be adopted, and the specific methods to be applied in data gathering, analysis, interpretation etc. What is needed from a theoretical approach in this research is a methodology, which will yield empirical data. This empirical data will then provide a basis for principles for the design of multimedia learning material (fig. 9).

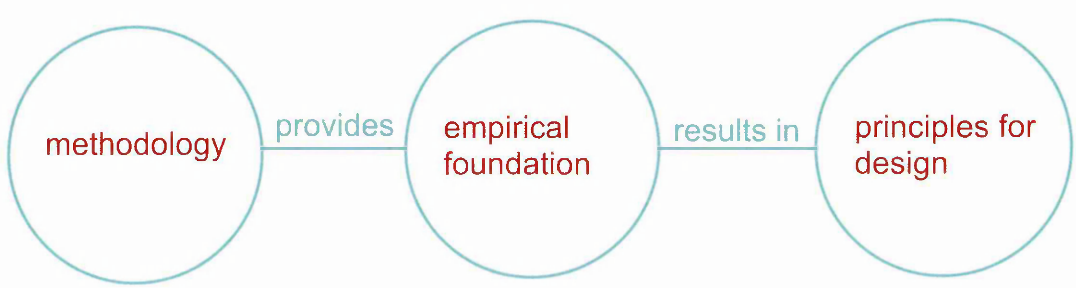

Figure 9 The link between methodology, an empirical foundation and principles for learning environment design

3.4.1. Positivism

The positivist tradition is a direct descendant of objectivism. It has its origins in the use of reasoning by scientists as a way of arriving at a universal truth which is presumed to exist as a given in the natural world. Deductive reasoning is therefore the basic starting point for theory to evolve. The notion of an 'ideal' in knowledge was supported by positivists maintaining that truth exists as a given in nature.

As regards this research in particular, positivism is less able to deal with the complexities of human nature:

'Where positivism is less successful…is in its application to the study of human behaviour, where the immense complexity of human nature and the elusive and intangible quality of social phenomena contrast strikingly with the order and regularity of the natural world. This point is nowhere more apparent than in the context of classroom and school where the problems of teaching, learning and human interaction present the positivistic researcher with a mammoth challenge.'

(Cohen, Manion and Morrison, 2000(f): 9)

Wittgenstein's logical positivism is based on the 'principle of verifiability', the idea that *'no statement is meaningful unless it is capable of being verified'* (Crotty, 1998(a) : 25). While certain statements can be verified through analytic reasoning, yet again the problem stands, particularly in the context of this research:

'This line of thought excludes metaphysics, ethics, aesthetics and religion from the purview of genuine philosophy. Metaphysical viewpoints, ethical values, aesthetic judgements and religious beliefs are, as such, unverifiable in the empirical manner determined by logical positivism. They do not deal in facts and are therefore of no interest to logical positivism. Emotionally, perhaps even spiritually, they may be of great value to people, but cognitively they are meaningless – nonsense, even.'

(Crotty, 1998(a) : 26)

The emphasis on the purely factual and therefore verifiable characteristic of positivism, places it in conflict with what this research is trying to understand and bring intervention in. Creativity is complex. It has never been characterised in a way that makes it readily measurable or even observable, except by its products. Whilst it is possible that a positivist approach could "measure" creativity by applying some rigid criteria to such products, this is unlikely to be of use to research aiming to support the complex processes, which underlie creativity, particularly as these processes themselves would be difficult to investigate using a positivist approach. An approach to methodology is therefore needed which allows for a descriptive account of students' experiences, which would be capable of capturing the emotional and affective factors impacting on students' creativity. If we take as an example the factors identified within the Nuffield QCA investigation into creativity, (Rutland and Barlex, 2002) the need for stimulus, self-esteem, self-management, relevant context – the common ground linking these factors, is that they are all in one way or another, related to the affective perception of learners. It would therefore be impossible to simply apply a form of quantifiable or verifiable measurement, which could throw light on how these are utilised or perceived by students, or on how students relate to these factors. An interpretative method - one which aims to describe, not quantify experience - is necessary.

Positivism has been further attacked by anti-positivists on the grounds of its mechanistic, reductionist approach, which:

'excludes notions of choice, freedom, individuality and moral responsibility'

(Cohen, Manion, Morrison, 2000 : 17)

This is a significant point considering that this research draws its starting point from the need to enhance creativity in education, and aims to identify factors, which make creative thought possible in the D&T classroom. As discussed in the previous chapter, creativity is associated and conditioned by these precise qualities of free will, individuality (an autonomous learner) and responsibility (students taking control of their own work). An approach to theory, which does not address these complexities in human development, could not adequately support the purposes of this research.

3.4.2. Constructivism

In contrast to positivist approaches constructivism offers a more human-centred approach to knowing. Naturalists see meaning making as an active process, rather than a series of rule governed laws. The person is seen as acting in the social world and creating this world proactively. In this sense meaning is made, not given and the knower is the active element in the creation of meaning. Crotty defines the epistemology of constructivism in the following way:

'...all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction with human beings and their world, and developed and transmitted within an essentially social context.'

(Crotty, 1998(a) : 42)

In critically evaluating the relevance of constructivism as a theoretical perspective to adopt within this research, the significance and implications of learning and knowledge as a social construction need to be explored.

Learning and knowledge as a social construction

From its very origin, constructivism has been divided into two, seemingly opposing, perspectives on learning - empiricism and rationalism (Howe, K. in Phillips, C. 2000). Empiricists view learning and all cognitive processes as a direct result of sensory perception. According to them the mind is only involved in making sense of reality after the senses have perceived and to a large extent already formed a reality. On the contrary, rationalists argue that the mind is involved in the processes of knowledge construction and works independently of the act of perceiving, therefore it is the mind, rather than sensory perception, that shapes our understanding of the world.

Kant's analysis of constructivism synthesises these two branches of constructivism and see them as complementary rather than opposing. In his view:

'A conceptual scheme without sensory data is empty, sensory data without a conceptual scheme are blind.'

(Howe and Berv, 2000 : 21)

In Kant's account perception and rational thought are accepted as contributing in equal strength and significance to the construction of meaning. This idea is carried further in developments of constructivism. As discussed in section 2.3.2, truth is seen as a construction at which people arrive through acting in and experiencing the world, i.e. - truth and all knowledge are a social construction. Further, the process of meaning making as knowledge construction implies speaking; the process of learning in turn implies a dialogue, as discussed in section 2.3.2. In this way meaning or truth is said to be essentially a social construction.

This idea of learning as a social construction however, also underlies the main critique of constructivism as an epistemology - is the mere agreement on a certain issue within a community of people enough to claim it is truth? Will the opinion of the minority, or one individual's opinion be considered false on the grounds of not being accepted or agreed in the majority? Is truth nothing more than a convention agreed by the majority?

In response to this critique the theory of constructivism maintains that individual conceptions are in themselves necessarily the result of a social construction, and a development from conventional thinking. Learning and knowing from the naturalistic perspective are therefore seen as situated and co-produced by social context. In terms of the implications this makes for methodology, Crotty defines:

> *'...the need to focus social enquiry on the meanings and values of acting persons and therefore on their subjective meaning-complex of action.'*
>
> (Crotty, 1998(b) : 69)

This approach underlies the learning theories discussed in section 2.3.2 of Vygotsky and Lave and Wenger.

We can therefore accept that, if constructivism is adopted as epistemology - a theoretical perspective overlooking the research - it would bring with it the implications of meaning, knowledge and truth as socially constructed.

Implications of constructivism for the design of learning material and for the design of the study

In the first instance, constructivism has two main implications – one for the design of the methodology of a study and the other concerning the design of learning material, which responds to students' learning needs.

Firstly, in constructivism learning starts from the *'knowledge, attitudes and interests'* of students (Howe in Phillips, D. 2000). Learning is a direct result of the way these characteristics interact and are experienced. In other words - instruction should consider students' natural ways of sense making and learning and use these as building blocks for the design of all teaching and learning material.

Secondly, instruction, or any resulting learning material, must *interact* with these natural learning patterns, and act as a response to them. The significance of this approach is that it would allow the student to construct knowledge in their own time and in their own terms, rather than being the receiver of instruction, which is imposed on them artificially.

One major implication this makes, and the reason why constructivism is regarded as difficult to implement, is that in order to have a basis for designing learning material the designer / researcher has to have an in-depth insight into the knowledge, attitudes and interests of students, which constitute the students' natural learning strategies. As Howe and Berv put it:

'because it requires knowing a good deal about students' starting points, it is much more demanding than subject centered, authoritarian approaches to teaching.'

(Howe and Berv, 2000 : 31)

Knowing about students' natural learning strategies implies a research methodology, which allows for exploring students' knowledge, attitudes and interests.

Having established the stance of constructivist research and its relevance to the present research, we can start looking more closely at the varieties in approach which constructivism subsumes. These are formulated as schools of thought. The following section critically explores their differences in view of identifying the approach, which would best support the researcher in establishing students' learning needs, their knowledge, attitudes and interests.

3.4.3. Schools of thought

The constructivist tradition provides the origin of three distinct schools of thought, which have been extensively applied and adapted within educational research. These are:

- phenomenology
- ethnomethodology
- symbolic interactionism

(Cohen, et. al., 2000)

The key characteristics, which bring these together as research methodologies are an emphasis on qualitative methods of data gathering and analysis, as well as a focus on phenomena - i.e. what is apprehended daily with our senses. All of these methodologies therefore rely to a great extent on subjective experience.

Ethnomethodology

Ethnomethodology has a focus on everyday life as the basis of the theories it generates. It is *'concerned with how people make sense of their everyday world'* and with *'the mechanisms by which participants achieve and sustain interaction in a social encounter.'* (Cohen, 2000(f) : 24) It is therefore the environment in which social interactions develop amongst people which forms the focus of ethnomethodology, as well as the conditions and factors in which these interactions develop and are sustained.

Symbolic interactionism

Symbolic interactionism focuses on how social situations influence the way people make meaning. Symbolic interactionists do not believe that it is people's individual characteristics, which are the key actors in producing meaning, but rather that social interactions produce the order of things and the way situations are resolved. Any order, meaning, or the way a situation is resolved is not merely existing or ready made but is rather *'negotiated'* and *'worked at'* (Bryman, 2004: 17). It is these interactions, which produce meaning and reality which symbolic interactionists are interested in.

For symbolic interactionists a person is someone only when they become part of a community and start to accept the norms and conducts typical for that community. Thus in order to understand the individual, the researcher must understand their culture. This has a direct bearing on the aims of the methodology arising from the interactionist approach. A central notion of symbolic interactionism is *'putting oneself in the place of others':*

'Methodologically, symbolic interactionism directs the investigator to take, to the best of his ability, the standpoint of those studied.'

(Crotty, 1998(b) : 75)

A further implication of symbolic interactionism for methodology concerns the role adopted by the researcher in understanding the situation studied. The view of the researcher is as that of an 'actor' (Crotty, 1998(b) : 75). This is also characteristic of the idea of full participant observation, as practiced by ethnographic researchers who immerse themselves fully in the culture studied in order to be able to experience the world from the point of view of the subject studied.

While full participant observation is possibly the most thorough and responsible approach, which a researcher can adopt in understanding the behaviour of the sample in their social world, this method is primarily emerging from a strong focus on the culture in which this behaviour occurs. In the context of this research, however, where students' learning needs are concerned, the researcher needs to take a step back from the culture, which is seen as contributing to the issue of lack of creativity in D&T classrooms (Kimbell, 2000). In understanding learning needs, this research aims to instead place a focus on students' own articulation of the issue, hear the data as spoken by the subject studied – in this case - A level D&T students, rather than as spoken by the culture which conditions the existence of the issue in the first place. In this sense the theoretical perspective of the research becomes closer to that of phenomenology – the idea of going *'back to the things'* (Crotty, 1998(b) : 78) and first experiences, which will be discussed in some detail in the following section.

As Cohen accounts, one of the observations and a grounding principle of symbolic interactionism can be expressed as:

'Individuals align their actions to those of others'

(Cohen et. al., 2000 : 26).

While the way this alignment happens, and is negotiated by people is the focus of the symbolic interactionist approach to analysis, and culture is seen as a positive experience, it is something phenomenology is rather more cautious about embracing. In this respect Crotty maintains that phenomenology and symbolic interactionism differ quite sharply, particularly in their view on culture. While symbolic interactionism places meaning making as indelible from the culture in which it develops, phenomenology sees culture as *'crippling'*, in being prescriptive and in narrowing the possibilities of the individual for action.

In the case of this research, which focuses on the value of divergent, original thought, and in looking for ways to nurture such thought as well as the attitudes, which accompany it, learners aligning their actions to those of the culture which accommodates them may not be the researcher's best bet. It is the diversity of thought that a creative classroom needs to nurture and which seems to be absent in the present culture of teaching and learning (Kimbell, 2000(b)).

This brings us back to the dualism existing within social construction as professed truth - the collectively agreed truth of the majority and the rather more solitary truth of the individual. The first is a product and a direct expression of culture. The second however is no less influenced by culture, even if it is a personal construction. A direct example from the classroom is that the experiences of students can never be completely dissociated from the influence of the culture, which accommodates them. In methodological terms this would mean that elements of ethnography would still be necessary in the approach adopted to data, even if research does embrace the notion of starting from the individual, and reducing the emphasis on the culture, which conditions the individual.

The following section discusses phenomenology as the alternative to symbolic interactionism, which offers an approach to data closer and more truthful to students' experiences, to their knowledge, attitudes and interests, and generally provides a methodology which uses students' experiences as a starting point for its analysis.

The educational debate and phenomenology

The divide of constructivism as socially engaged or individually-cognitive, as discussed in section 2.3.3, overlaps the truth as a social construction debate, however is distinct and relevant to this research in exploring these issues more directly from the point of view of learning.

From the standpoint of identifying a theoretical perspective for research, the question posed is: Is creativity an act of individual cognitive thinking or a social construction? From the point of view of educational research, Laurillard quotes Marton and Booth in a critique of this divide within constructivism into 'individual cognitivism' and 'social cognitivism'. She argues for a merging of the two:

'Whereas the former situates the explanation of learning in the learner's cognitive mental acts, the latter situates it in their social external behaviour. Marton and Booth argue that we have to transcend the person-world dualism assumed in both forms of constructivism, and accept that the world that we experience is constituted as an internal relation between the world and the learner'.

(Laurillard, 2002(c) : 68)

According to Laurillard (2002(c) : 68), *phenomenography* (in other accounts also known as phenomenology) as a theoretical perspective bridges this divide, taking into account both individual constructions of knowledge and socially constructed knowledge as equally important.

Phenomenology

Phenomenology's distinctive feature is that it places phenomena - what is perceived - at the centre of meaning making or learning. It further emphasises the individual construction of knowledge by the learner as the key to students' learning. However, it is important to understand that it is not the individual characteristics of the learner which produce meaning, but rather the interaction between the environment and the characteristic activities occurring within this environment, which constitute knowledge.

Such an approach is necessary within this research, where the aim is to break away in its intervention from the conventional norms which the D&T classroom culture may have imposed on students, and which, as research literature shows, seems to have led to a stale culture, preventing learners from thinking creatively (Kimbell, 2000(a)). The fact that there is an issue with creativity being compromised by the norms of the classroom environment has also been emphasised in the 'All Our Futures' report (NACCCE, 1999).

This is why this research places its beliefs in the phenomenological approach to theory, where students' own perceptions and experiences shape the nature of the intervention, which will be produced, not the culture in which learners learn.

At the stage of identifying students' learning needs, research purposefully avoids taking the symbolic interactionist theoretical perspective because this would mean starting from the already existing culture. As was explained previously, the existing culture is seen as co-producing the issue of lack of originality in students' work. It is not therefore the teachers' account of creativity and originality that this research is interested in, nor the norms or conventions applied, which have so far aimed to deal with the issue of creativity in students' work. This research aims to start with a clean slate, and an open mind, looking at students' experiences, and the phenomena, which they describe.

One example of how a phenomenological approach has been applied in researching creativity, is a study carried out by Grant (Futurelab Web Articles, Researching Creativity: An Experiential Methodology) on children's experiences of a dance workshop. Instead of identifying the categories of research as a starting point for data, the researcher starts with an exploration of children's perceptions of creativity. The researcher asks children to represent their experience, memory of learning in a dance and music workshop, through drawing a picture. The premise with this approach is that:

> *'This phenomenographical approach is based on the idea that the way individuals or groups choose to represent their experience can tell us something about how they are thinking about that experience... Children's drawings were representations of their experience of the workshop, but also reflections on it, a creative learning experience in its own right.'*
>
> (Grant, 2005)

This is an example of how data can be generated in a way which starts purely from the learner's experience, not from the culture in which the learner develops their understanding and not from any extrinsic factors acting on the learner. The positive side of phenomenology is that the so-called exploratory or phenomenological studies do provide an empirical basis for the design of a learning environment, which is what this research aims to achieve. A phenomenological study explores students' perceptions and experiences of learning. Based on this, it draws empirical data on which a teaching strategy can be founded.

There is one aspect of this type of study however, which makes it debatable as a suitable methodology for this research. The difficulty of a phenomenological approach is that its outcome is usually formulated as categories of experience (Laurillard, 2002 (f) : 29). The need for categorisation is based on the idea that for any learning situation there is a limited number of ways in which a topic can be perceived, therefore - a limited number of misconceptions in understanding on the side of the student can exist. By studying those in the particular learning situation, for a particular topic, phenomenology aims to predict and make provisions for all possible perceptions / misconceptions, and adjust the teaching strategy accordingly.

This model of studying categories of experience, although empirically grounded is primarily suitable for and described in Laurillard's account of it, (Laurillard, 2002 (f): 29) in view of subjects, which would require explicit knowledge - such as physics or maths for example. It is possible that there are indeed only a certain number of ways in which Newton's Law can be perceived, and a limited number of misconceptions. When trying to teach knowledge the outcome of which is creativity however, things are not as clear-cut. Crucially, if any form of teaching of creativity is to be considered plausible, it needs to be seen as an attempt to encourage independent thought in the learner. The model of the teacher who tries to learn about students' categories of experience is therefore unsuitable in this case. Further it is unlikely that any experience of processes involving or leading to creative thinking would yield categories of misconceptions.

The phenomenological approach therefore needs to be flexible, avoiding categorisation. A more unrestrained free-speech model, where learners talk about their experience of creativity and D&T in the classroom in general needs to be adopted alongside the phenomenological approach.

Therefore a mixture of theoretical perspectives, phenomenology alongside symbolic interactionism, is what defines the choice of a methodology for research, and as will be discussed in the following chapter – formulates it as action research with elements of ethnographic enquiry.

Chapter 4. Methodology of the Learning Needs Interviews

4.1. Introduction

This chapter describes the methodology adopted within the Learning Needs interviews – a series of three phenomenological studies aiming to establish D&T students' perceptions and experiences of creativity in the classroom.

The approach to data analysis adopted – grounded theory and the constant comparison method - is discussed in terms of how it relates to the study and in what way its characteristics contribute to the purposes of the study.

The interview schedule is described in detail, making explicit how each question aimed to contribute to a fuller understanding of students' experiences of creativity. This detailed discussion of the interview questions is included in the thesis in order to address the issue of translatability facing ethnographic, qualitative approaches to research. Each question is related to the literature survey carried out and references are made to specific instances of how the research questions relate to the concerns of related studies in the field.

The chapter further describes Atlas/ti - the software used for data analysis and how ethical issues were addressed.

4.2. Style of research methodology - an approach to action research with elements of ethnographic enquiry

4.2.1. Phenomenology

Two key features of ethnography were utilised within this research. Firstly, hypotheses and theories were generated, not tested. Secondly, students' points of view and experiences of learning were central and constituted the main source of data in the generation of hypotheses and the formation of theory. Thus research was concerned with the subjective experiences of students within the D&T classroom, which in turn suggested a qualitative approach to data. This concern with personal experiences made the approach similar to that of phenomenological studies as described by Laurillard:

'Exploratory studies attempt to describe the characteristic ways of conceptualising and learning a topic that can be found in the student population, without identifying the characteristics with individuals. Some of these studies are also known as 'phenomenographic', because they set out to find characteristics in the form of students' descriptions of the phenomena, in contrast with studies that set out to explain student behaviour by finding relations between predefined characteristics.'

(Laurillard, D., 2002 (f) : 28)

Laurillard maintains that by being descriptive of students' experiences the phenomenological approach provides a firm foundation on which a teaching strategy can be based. A similar approach of using phenomenology in the D&T education field, was used as a base study for the Design Against Crime project, aiming to establish D&T pupils' understanding and perceptions of issues of citizenship (Lewis, Chapman and Smart, 2004: 129).

Students' point of view

Ethnography involves *'the description of activities in relation to a particular cultural context from the point of view of the members of that group'* (Cohen, 2000 : 52 – 3). A *'particular cultural context'* - in our case the subject of D&T - is also what Laurillard maintains as central in her idea of learning as situated in a specific subject domain (Laurilard, 2002 (d) : 19). The statement *'from the point of view of members of the group'* is in line with the nature of a phenomenological study, already discussed in Chapter 3 as an approach to generating a teaching strategy, i.e. exploring students' perceptions and understanding of various phenomena. This is also supported by LeCompte and Preissle who say:

'The world view of the participants is investigated and represented – their 'definition of the situation.'

(Cohen, 2000 (d) : 138)

Once again the students' point of view was seen as the source of generating theory.

The generation of theory

Spindler and Spindler propose several characteristics of ethnography, which this study has observed:

- Hypotheses emerge *in situ* as the study develops in the observed setting.
- The ethnographic interviewer should not frame or predetermine responses by the kinds of questions that are asked, because the informants themselves have the emic[1], native cultural knowledge.
- Codes and agenda for the interviews should be generated *in situ*

(Cohen, 2000 (d): 139)

Ethnography is an 'emic' approach – i.e. it is concerned with understanding the subjective meaning placed in situations by participants. Subjective meaning rather than objective truth is its goal. Therefore data gathered and analysed within the Learning Needs interviews was necessarily subjective. Further, it did not aim to test hypotheses. Hypotheses were allowed to emerge *in situ.*

The development of hypotheses is one of the definitive characteristics of ethnography. Genzuk (Genzuk, 2004) identifies a basic principle of ethnographic research, which sees the research process as 'discovery-based', rather than testing hypotheses, it generates hypotheses from fieldwork. Correspondingly, the questions posed to students within such a study should be kept open ended, where responses are neither expected, nor predetermined in any way. Only general areas of enquiry were outlined, based on research literature of the nature of creativity (see Chapter 1). In this way, the data generated did not aim to find proof of an existing hypothesis, it only aimed to suggest possible truths, thus generate hypotheses.

LeCompte and Preissle also pinpoint that *'there is a move from description and data to inference, explanation, suggestion of causation, and theory generation'* (in Cohen, 2000 (d) : 138). This implies that to an ethnographic study adopting a grounded theory approach to data analysis and interpretation is natural, where theory is generated from the data – it emerges from it and is grounded in the data gathered. The emphasis is on interpretation, inference and suggestion.

[1] Subjective

4.2.2. Action research

Action research is an attempt to bring theory and practice together, the ultimate aim of research being to improve practice. Action research therefore necessarily involves a perceived intervention:

'The task... is not merely to understand and interpret the world but to change it.'
(Marx in Cohen, 2000(c) : 226)

This research aimed to contribute to a theory of education in generating a teaching strategy to be implemented in the design of interactive learning environments. It also contributed to practice by giving suggestions of how to put this theory to practice.
In another definition, Kemmis and McTaggart state:

'Action research ... does not start from a view of 'problems' as pathologies. It is motivated by a quest to improve and understand the world by changing it and learning how to improve it from the effects of the changes made.'
(Cohen, 2000(c) : 227)

This statement highlights an important stance, which this research has adopted - the goal of researching the learning experiences of students in the D&T classroom was not to resolve a problem. It would be overly ambitious for this research to criticise or claim to reform existing teaching and learning practices. Instead it looked at ways of supporting and enhancing processes and practices which were already in use, extracting the positive aspects of these and using a new medium to deliver the result.

Action research as a process

Kemmis and McTaggart describe the process of action research:

'Action research develops through the self-reflective spiral : a spiral of cycles of planning, acting (implementing plans), observing (systematically), reflecting ... and then re-planning, further implementation, observing and reflecting.'
(Cohen, 2000(c) : 229)

Within this research the stage of gathering data through the Learning Needs interviews was followed by practical implementation and evaluation, which led into a new cycle of data gathering.

According to Blum there are two simple stages of action research:

- Diagnostic stage - the problems are analysed and hypotheses developed
- Therapeutic stage - the hypotheses generated are tested by ' a consciously directed intervention or experiment *in situ'.*

(Cohen, 2000(c))

Within this research the diagnostic stage involved identifying students' learning needs, and generating hypotheses regarding what D&T students needed from learning within the subject, from the point of view of creativity.
Approaching methodology from a phenomenological perspective, research sought to understand learning needs from the learners' viewpoint, to grasp their subjective interpretations of creativity. The therapeutic stage involved evaluating the hypotheses generated, through designing an IMLE (interactive media learning environment) and carrying out field studies with D&T A level students using the system. The evaluation is necessarily seen as formative, as opposed to summative, having as one of its outcomes suggestions of how the design and theoretical principles of the learning environment can be enhanced.

The process of action research usually begins with a general idea of what the issues are and where the hypotheses may lie (McTaggart, 1996; Lewin, 1946). The following is a plan for action research by Kemmis and McTaggart (Cohen, 2000(c) : 234), interpreted in the context of this research (fig. 10). Each of the steps of the action research plan given by Kemmis and McTaggart, (shown on the left hand side), has its corresponding interpretation in the context of this research (shown on the right hand side).

Plan for action research by Kemmis and McTaggart	Plan for research into multimedia for enhancing creativity in D&T education
1. Forming a general idea of the improvement or change - the desired intervention	Within this research the general idea has been formed initially through a literature survey exploring the definition of creativity and its application within D&T classroom practices, and further elaborated on by the findings of the Learning Needs interviews.
2. Deciding on a field of action	The general idea formed, further prompted a *field of action* - it highlighted where research could have an impact. This was one of the key outcomes of data gathered by establishing learning needs - where exactly should the focus of learning material fall? Where was multimedia technology as a learning aid likely to have the most significant impact?
3. Deciding on a general plan of action	This concerns deciding the methods and scope of the study. Decisions had to be made regarding how many focus group interviews to conduct; what was the envisaged outcome from these interviews; the consequent stages of developing and evaluating a multimedia learning environment also needed to be considered.
4. Breaking down the plan into achievable steps	The specific stages of research were identified and a timescale for each stage developed.

5. Devise a way of monitoring the effects of the first step	Techniques and methods were chosen for evaluating A level students' perceptions and thoughts about creativity in the D&T classroom.
6. First step is taken	The first step in the case of this research was the data gathering and evaluation of the Learning Needs interviews.
7. New data starts coming in	Data from the Learning Needs interviews was interpreted, yielding suggestions for the design of the learning environment.
8. General plan is revised in the light of the new information	A framework of questions was developed, emerging from the literature review initially and further detailed by the findings of the learning interviews. This framework was used to guide the evaluation of the learning environment.
9. Planning of the second step along with monitoring procedures	The data gathering and interpretation methods to be used within the IMLE were established on the basis of the framework of questions indicating what was the focus of observation.

Figure 10 Plan for an action research methodology – adapted from Kemmis and McTaggart

4.2.3. Action research or ethnography?

Action research provided a coherent framework for this research, but the data gathering approach also had to focus on students' perceptions in order to understand the learning processes they went through. From this point of view the research needed to be grounded in ethnography. Ethnography is more specific in its definition as a method of research as well as its output form - i.e. - a narrative description (Genzuk, 2004). It is also valuable in the theoretical perspective, which it adopts to describe the research. On the other hand it is quite reluctant to provide a framework for research.

Further, ethnography does not include the notion of intervention, which is an important element of this research. The design of an interactive learning environment was the basic means of testing hypotheses, which emerged through the Learning Needs interviews. Creating an intervention in students' learning through using this learning environment was a key function of this research. While it is not mentioned in ethnography, a positive intervention is characteristic of action research. Furthermore, action research is descriptive of the process the researcher has to follow. It offers an appropriate framework, which not only accommodates but also offers a valuable description of the transition from theory to practice. In terms of the iterative process of planning, action, data gathering and reflection - action research was important in the framework it provided for research.

The two styles of research therefore needed to be combined to provide both a theoretical perspective and an overall framework. This research adopted a hybrid style, which can be described as action research with elements of ethnographic enquiry.

4.3. Interviews

4.3.1. Data gathering - Focus Group Interviews

The focus group interview method was especially suitable for the purposes of this research. The interview technique focused on discussions which naturally developed among participants, rather than being a question and answer exchange between interviewer and participants. In this way *'the participants' rather than the researcher's agenda can predominate'* (Cohen, 2000 (a) : 288). In particular this was valuable in the type of output this research was looking to generate - students' attitudes, their understanding of what was valuable in learning, and what the difficulties in the process were. Focus groups were especially useful in *'generating hypotheses that derive from the insights and* *data from the group'.* (Morgan in Cohen, 2000(a) : 288). Accordingly the research aimed to approach the generation and analysis of data in an open way, without preconceptions, expectations or ready hypotheses. Questions regarding students' experiences of learning as situated in the D&T subject domain were open ended, seeking to generate, as opposed to test, hypotheses. General areas of enquiry within the interviews were based on the directions which literature review on creativity in D&T education had identified. The attitudes and perceptions of students were explored through interviewing.

Locating the field of study

A series of three focus group interviews were carried out with A level D&T students within the Sheffield Educational Authority. Each of the three interviews lasted approximately 1 hour. The largest group consisted of 10 students and the smallest - of 3 (see fig. 11).

School	**Number of students participating in interview**	**Subject and level of study**
School 1	3	D&T AS level
School 2	4	D&T AS level
School 3	10	D&T AS level

Figure 11. Students participating in the focus group interviews

Questions

The interview schedule followed a semi-structured approach allowing for questions to evolve in their emphasis, detail and structure according to students' responses. As is characteristic of focus groups, questions were open-ended, offering a general area for discussion without being definitive or restrictive in the direction in which the discussion should develop. Hypotheses were gradually formed in light of students' answers and opinions. Accordingly, as the research developed an understanding of where the really interesting issues in the context of this research lay, the interview questions evolved.

Pilot study

Prior to interviewing in schools, the interview schedule was trialled within a pilot study, aiming to evaluate the meaningfulness and focus of the questions as well as their potential for instigating discussion within the focus group. Four Product Design students in their first year of undergraduate study participated.

Convenience sampling was used. The two other selection criteria were the level of study of participating students and the subject studied. In their first year of study, undergraduates are not too far removed from their A level learning experiences. Further - the subject of Product Design is a natural progression for students in their A level year of the D&T discipline in secondary schools.

Recording

The actual interviews in schools were video recorded in order to obtain data of the participants' non-verbal communication alongside their verbal comments (Heath, Hindmarsh, 2002). Video recording was especially useful in capturing data from questions which were either task related, or involved the analysis of visual material.

Access

A number of schools were identified as appropriate to participate in the study. The basis for selection was that the school should have a track record of offering A level D&T. Availability of ICT hardware was another criterion for selecting schools.

The schools identified were invited to participate in the study. Initial contact was established by letter, followed by meetings with the Head of Department for D&T in each school. The purposes of research were made explicit, both verbally and in writing. Prior to any contact with students I obtained a criminal record clearance.

Informed consent

Students asked to participate in the interviews were given the option to withdraw at any time. Further, before commencing each interview they were again reminded of the option to withdraw and given an opportunity to ask questions about anything that may have been unclear concerning the process (For example of this procedure, see Appendix 2, Introduction). Issues of confidentiality were also addressed - participants' real names were altered within all interview transcripts.

Video recording

Students were informed prior to the date of the interview that they would be video recorded and the purpose of recording was made explicit to them. In some cases where students were younger than 18, letters were written to their respective guardian / parent requesting permission and explaining the purpose of recording, as well as how and where the videos would be used.

The researcher established verbally and in writing, that the video recordings were not to be shown outside the immediate research community (supervisory team, advisers, researchers involved directly or indirectly with this project, conferences), or used in any way other than within the immediate context of the research.

Comparability and translatability

A common critique of ethnography as a research methodology is that it fails to be scientific and generalisable. According to LeCompte (Cohen 2000(d) : 139), ethnographic research will be able to address the positivist issue of generalizability if it incorporates:

- Comparability – the characteristics of the group being studied need to be made explicit so that comparison with other similar groups can be made.
- Translatability – the categories, which the research uses, should be made explicit so that parallels with other studies can be drawn.

Comparability and sampling

Students from all three groups were either in the beginning or the end of their A2 year of the D&T course. Students therefore had comparable experience of the processes and practices of designing. Furthermore their experiences of designing and creativity could be seen as indicative of the experiences of an A level student doing D&T, which allowed for a sufficient degree of generalisation of the research.

Convenience sampling was used for the interviews. Where possible, an equal number of boys and girls were selected as participants. Availability was however the main criteria in selecting students.

Translatability

The initial categories of enquiry were shaped by research into the literature on creativity in D&T education. The basic areas of enquiry were outlined by the conditions of creativity identified through research literature (see Chapters 1 and 2). The Nuffield QCA Project is one example of how these conditions and factors for enhancing creativity within an educational context were applied within a study of D&T students' responses to projects aiming to apply these principles. These principles can be summarised as:

- context building;
- stimulus necessary for creative activity;
- encouraging reflective thought;
- supporting risk taking and autonomy;
- managing these processes successfully.

Additional aspects of creativity identified as relevant within the wider research literature on creativity and learning beyond the context of the D&T classroom, were experiential learning, collaborative work and intrinsic motivation (Hennessey & Amabile, 1988). These were used as the basis for identifying areas of inquiry, formulated as questions, which in turn provided a framework for data gathering.

4.4. Interview questions

The following section describes how each of the interview questions emerged from a more general area of enquiry. In being descriptive of the questions' meaning, this section makes the categories of enquiry explicit and therefore translatable. It further describes how the focus of the questions changed over time as understanding of the really important learning needs developed, seen from the students' viewpoint.

4.4.1. Question 1 Context

The significance of context building to producing a creative outcome was discussed in detail in Chapter 1. To summarise, context building has a bearing on the type of design problems, which students investigate. The point of view from which they investigate these problems determines if the outcome of designing will be exciting and creative as opposed to dull and predictable. As an interview question this was initially framed in the following way:

'Imagine you have a brief to design a mouse for an internet café. What processes would you go through when gathering information?'

This question was trying to establish the range of sources students use for gathering information – how varied were they? Were they likely to lead them to knowledge, which could inspire creative thinking later on in the project? However, as tested in the pilot interview, the question was largely unsuccessful. The way the question was posed failed to engage participants in a discussion. The dialogue, which developed was mostly researcher-led, which is not desirable in a focus group interview.

In order to address these problems, the question was reformulated in two ways. Firstly it was posed in a more general way:

'When starting a new project how do you choose a subject for your design?'

Although general and abstract, this was an abstraction which students could immediately relate to since they could make the association with their own current design projects. To support this process of making such an association students were asked to tell the group about their ongoing self-directed project work (see appendix 3, Question 1). This was something everyone understood, therefore discussion developed naturally. The data this discussion yielded threw light on how students approached identifying a problem, what resources they used, as well as what contexts of research they would avoid.

4.4.2. Question 2 The design stages

'Once you have identified a problem to focus on (or a research area) how do you follow this up?'

The purpose of this question was to identify students' perceptions and experiences of designing. As informed by the phenomenological approach to learning theory (Laurilard, 2002(f): 30), what students expressed as their difficulties of how to go about designing, would inform the pedagogy to employ within a multimedia learning environment.

As participants in the pilot interview failed to engage in discussion and dialogue this question too had to undergo transformation.

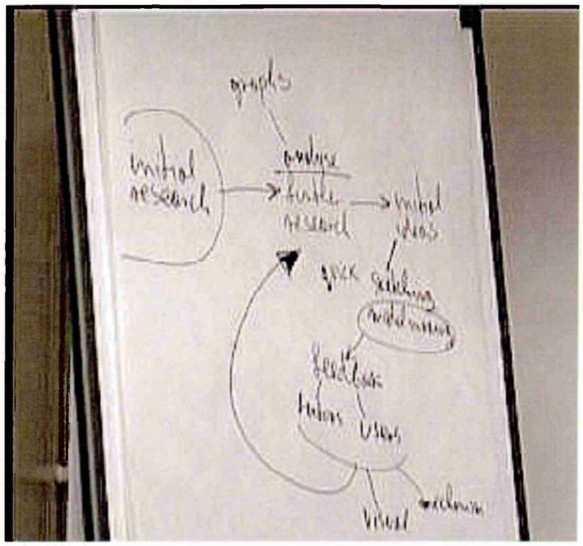

Figure 12 Using a flipchart

A flipchart was used as an aid for illustrating students' responses in the form of a diagram (fig. 12). This as well was rather unsuccessful, as it slowed down and inhibited the flow of conversation. To overcome this difficulty and to place the emphasis on discussion among students, the way the question was delivered was altered, placing the emphasis on a hands-on activity for them to engage in. Students were given a basic, linear diagram of key stages in designing (see fig. 13). Students were then asked to draw an arrow linking each stage of designing to others, in this way focusing on the non-linear, sub-processes taking place within the more obvious linear process.

The nature of the task itself was collaborative, which further supported discussion amongst students. They had to reach an agreement through discussion on what link to make and which relationships to apply. Reaching an agreement necessitated dialogue and discussion. It was within this discussion that active thinking on students' part occurred.

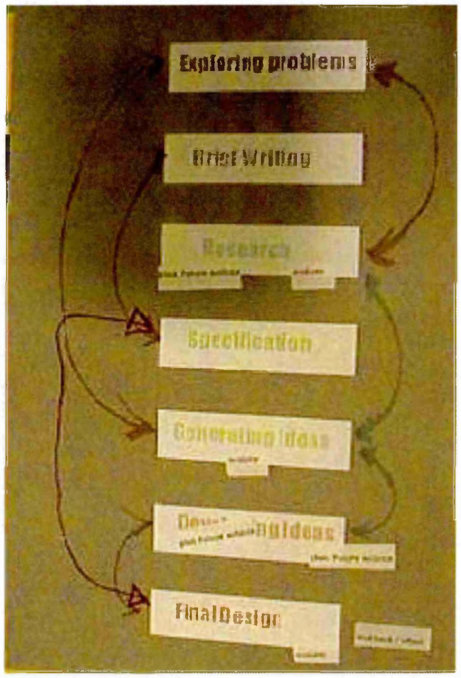

Figure 13 Diagram of the key stages in designing- completed by students.

As a result, this question yielded a number of useful insights on how students perceived the act of designing, and the difficulties, which existed within this.

4.4.3. Question 3 Students' priorities and creativity

Among the factors necessary for creativity to occur, the All Our Futures report (NACCCE, 1999) identifies the process of moving from generating ideas to developing ideas as one of the crucial stages in creative development. This transition from generative to reflective thought is important. Students' perceptions of how this works were indicative of how they manage the process and what their difficulties were within it. Furthermore, this transition from reflective to generative thought was often influenced by the factors surrounding the decision-making process of students selecting their self-directed projects.

The question explored the criteria, which students applied in selecting an idea to progress. This had to necessarily be placed in context, because asking students about their priorities would be too abstract for them to be able to comment on adequately. The question was posed as a task, in which students had to select one of three ideas to progress (see Appendix 1, Question 3). The three ideas varied in the degree of creative control they afforded to the learner. The purpose of the question was to challenge students to explain their choice, thus gaining an insight into the nature of their motivation when engaging in a project idea.

4.4.4. Question 4 Inspiration / Stimulus

Analysing existing products is one of the well-established techniques for learning about design. Once again, drawing on the phenomenological approach, this question aimed to explore students' approaches to analysing a product. Conclusions were consequently drawn about how their understanding could be enhanced, and their thinking supported. The question was framed in the following way:

'Look at these images of products: where did the designer get their inspiration from?'

The degree to which students were capable of recognising where the inspiration came from gave an indication of how well they were acquainted with, or confident in working with, various ways of drawing inspiration themselves (fig. 14).

Figure 14 Existing products used as the basis for discussion in question 4.

The concept of stimulus as a necessary condition for creativity was also explored in this question. The purpose of inspiration is to act as a source of stimulus to the creative person. Therefore the question's goal was to explore whether students were aware of different techniques for drawing inspiration and on the basis of the depth of understanding they displayed, determine the role of interactive learning material, as well as its content.

4.4.5. Question 5 Where do you get your inspiration from?

This question was necessary in order to place the phenomenon of inspiration in the context of students' everyday experiences of learning. The analysis of existing products in terms of inspiration yielded different data from the analysis of inspiration and stimulus within students' own practice, which was explored in Question 4 (see section 4.4.4). In the first instance students expressed an understanding of techniques of inspiration as actuated in others' work. This allowed me to generate data on how familiar students were with different sources of inspiration. The analysis of inspiration and stimulus gave me an idea of how much of this knowledge they actively used and in the cases where they did not use it, what were the inhibiting factors.

4.4.6. Question 6 Which of these media have you used in your work? How is each of these helpful?

While the previous two questions explored resources used as stimuli, this question aimed to further explore sources of stimulus in students' work from the point of view of the medium used. It focused on students' awareness of the possibilities of different media to enhance their work. It further aimed to look into ways in which students in practice apply the media they have access to within the school. A list of the most commonly used media in D&T education was given to students *(see Appendix 1, Q6).* They were asked to discuss the relevance of these to their own work. From their articulations it became apparent what the issues of using these media were. It was important to explore these issues from the point of view of what students thought about the provision and relevance of the media available to them. This question was fruitful as a way of highlighting the differences between teachers' intentions and students' expectations of particular media.

4.4.7. Question 7 Collaborative learning

The literature review explored the potential of social interaction and dialogue to learning. Within the D&T classroom this social dimension is actuated through group activities - tutorials, brainstorming sessions, discussions. Dialogue occurs on a regular basis between teacher and students, and in a more informal way amongst students in everyday learning situations. These different facets of social interaction within the classroom contribute to the dialogic dimension of learning, which - as social constructivists would argue - is essential to any form of knowledge construction. The purpose of asking students to express an opinion about the different sides of social interaction was to be able to judge the value of each of these aspects from students' points of view:

Question 7 Think about group discussions. What do you need to discuss and who with?

- *Discussing as a group - where everyone contributes*
- *Yourself asking questions - of a tutor or of a friend*
- *Hearing about other people's work - in tutorials for example*
- *Getting feedback for your own work - from a supervisor for example.*

Within this question the key functions of dialogue within the context of learning D&T were explored. By asking students to explain in what way each type of dialogue was valuable to them, I acquired an understanding of which types of dialogue would be more likely to be exploratory - therefore leading to reflective, and ultimately creative thought, and which were more likely to result in a dispute.

4.4.8. Question 8 Autonomy and risk taking

The literature review identified autonomy as necessary for creativity to occur (Rutland and Barlex, 2002; Hennessey & Amabile, 1988 : 32). In brief writing the issue of autonomy emerges as a key consideration since it is at this stage that students have to take responsibility for their own work and define its parameters. The question asked students to comment on examples of other students' design briefs:

'Look at this student's design brief – is there anything major missing? What would you have changed to make it a more exciting brief?'

As is characteristic of a phenomenological study, this question aimed to explore students' experiences and understanding of brief writing. The question aimed to gain an insight into how aware students were of what constitutes a challenging and open brief, such as would be likely to lead to versatile research and yield creative outputs.

4.5. The role of video recording

The Learning Needs interviews conducted had as their aim to explore students' perceptions of learning, in tune with the phenomenological approach adopted. It was only natural that understanding perceptions and experiences was not solely a matter of analysing verbal interactions between people. This is why considering the physical side of social interaction was essential. In this way video recording was utilised in order to take into consideration the *'spoken, bodily and... material resources'* (Heath & Hindmarsh, 2002).

Following are three examples illustrating the different ways in which video recording proved valuable in yielding and interpreting data within the social interactions, which arose as part of the interviews.

Two of the questions in the interviews were task oriented. In the 'Design stages' question (see Appendices 2 and 3, Question 2) students had to work as a group in drawing the links between different stages of designing. Video recording served to illustrate the process in which students constructed their diagram.

Video material managed to explicitly show how many of the students engaged in this task actively, as well as the manner in which they engaged. In some cases a student pointed to a link but another drew the link. It was important to understand whether the majority agreed with the link drawn or not. Yet this act of agreement was in some cases only indicated by a gesture or a nod, rather than verbally.

Gestures and body language became important sources of data in Question 4, where students were asked to analyse existing products from an image (see Appendices 1, 2 and 3, Question 4). Within this question students' immediate reactions upon seeing the image were most indicative of their feelings about the product in the image.

Another example of the value of video recording was to show the effect of group interactions. Nuances of disagreement or agreement to the previous comment can be telling of students' way of thinking. Such elusive signs are often not expressed verbally, as described by Heath and Hindmarsh (2002: 15). One such instance was Question 5 in the School 3 interview: *Where do you get your inspiration from?* :

Researcher: *Which (form of inspiration) do you think is more valuable? Which do you find easier to work with?*
T: *Books. It's like when you are doing something for inspiration if it's your own inspiration then you have to do it from scratch. If you take it from a book you're already half way there. So basically you're just copying...*

This comment was valuable - it was indicative of the problem of students not being inspired, having an attitude of appropriation and copying towards existing products. Such attitudes are at the heart of the creativity issue in D&T education. Students' perceptions however were not clear from this single verbal articulation - it did not indicate whether the rest of the group agreed with what this student had said, if they agreed actively or passively or if this was the norm of thinking. Students' body language and reactions made me think that this way of thinking, as expressed by learner T, was not the norm, it was not universally accepted among students. On the other hand - no one verbally, objected to what T had said, which indicated some form of passive acceptance. In other words, what T had said was indeed the reality of the situation, even though students were aware that it was the wrong attitude to have. An important hypothesis was elicited from this exchange - students were aware that their way of working by 'copying' was wrong, however they lacked the stimuli to look elsewhere for inspiration.

To summarise, a significant part of the judgements elicited regarding students' perceptions were based on the analysis of body language. This brought in another way of looking at participants' responses and contributed to a richer understanding of their learning needs.

The following section progresses from methods of data gathering to describing the approach, which was adopted to the analysis of data. The section further describes the specific methods, which were used within a grounded theory methodological framework and makes explicit the particular role which each of these methods played in the interpretation of the data gathered.

4.6. Grounded theory - the constant comparison method to data analysis

The approach to data analysis which best supports the generation / emergence of theory is *grounded theory* as defined by Glaser and Strauss (1967(a)). The key outcome of the action research methodology is a desired intervention in the current practices under investigation. The link between action research and grounded theory is in the word 'generate'. While action research aims for a positive intervention, grounded theory facilitates the generative thinking process in allowing the researcher to generate theory, or come up with the new out of the data gathered. The learning environment, which was developed as an intervention in the teaching-learning setting researched, required a leap of creative imagination and it was the nature of the grounded theory approach – targeted at seeing relationships, making associations and drawing out new ideas from the existing data - which made this generative thought process possible.

In allowing us to generate theory the grounded theory approach supports the process of creative thinking which is necessary for a new idea to come to life.

Glaser and Strauss identify several possible methods of data analysis - analytic induction, constant comparison, and typological analysis (Glaser, 1967(b) : 101). In the first approach the researcher is looking to test hypotheses, in which case codes are established for the data, which are then analysed. Alternatively, if the researcher is looking to generate theory, the analytical effort is focused on analysis, and coding is unnecessary since the data is constantly reassessed, and reinterpreted in the light of new information.

There is a third approach, which is embodied in the *constant comparison* method of data analysis. Constant comparison combines the first two approaches in using coding alongside analysis. The coding in this approach is inductive - i.e. data is *'coded only enough to generate, hence to suggest, theory'* (Glaser, 1967(b) : 103). In this way major categories of analysis are identified. The researcher's main analytical effort is concentrated on the act of constant comparison and establishing interrelations between:

- the initial and emergent categories;
- incidents within a category.

It is this method, which this research favours.
The unique advantage of the constant comparative approach is that it combines the flexibility of qualitative theory generation with a quantifiable method - coding, which can be used at later stages of research for testing the theory through the use of more rigorous quantitative methods. This is especially important in the context of this research. While the Learning Needs interviews are a study of creativity - a topic requiring qualitative analysis not being easily quantifiable - the further stages of this research involve the production of a learning environment which has as its purpose evaluating the theory generated. It is therefore essential that the theory generated should be able to afford usability testing which involves a mixture of quantitative and qualitative methods.

4.6.1. Comparison with other methods of grounded theory

Following is a discussion of other methods of grounded theory against that of constant comparison. This discussion makes explicit the reason why constant comparison was considered the optimum choice of method within this research.

Typological analysis is useful in identifying key characteristics; data are put into groups, from which sub-categories are derived. On the basis of these separate categories key characteristics are derived (LeCompte *in* Cohen, 2000(d) : 152). Unlike *typological analysis* in the case of *constant comparison*, the categories formed have limited value on their own, and even less value as separate characteristics. They need to be compared to one another and the interrelations among those are used as a way of further identifying properties of the categories. It is in the cross comparison of the categories and their properties and the relationships existing amongst them that valuable data emerge.

In this way for example within the interview data analysis, multiple representations of data (MRD) emerged as a distinct category supported by a number of instances. Similarly collaborative work emerged as a distinct category of its own, also illustrated by what students had said. The theory generated from them however, emerged from comparing the two distinct categories, and establishing that there was a clear relationship between the two.

4.6.2. PowerPoint presentations

In accordance with the constant comparison method, the data in the Learning Needs interviews was approached by establishing general categories such as were suggested by the interview questions and students' comments - stimulus, collaborative work, creativity, feedback, autonomy (see Appendices 1, 2 and 3). In the process of data gathering and analysis these categories were gradually altered, detailed, shaped and illustrated by *evidence* - students' actual comments. This process is described in the grounded theory approach where *'In discovering theory, one generates conceptual categories or their properties from evidence; then the evidence from which the category emerged is used to illustrate the concept'* (Glaser, Strauss, 1967(a) : 23). In the case of this study, students' comments were used as the evidence, which illustrated categories and the properties generated from them.

As described previously, the purpose of coding in constant comparison is mainly to suggest or generate hypotheses. It is to allow the researcher to acquire an intuition of what the main categories and possible properties are. This process involves reviewing the data repeatedly, until an intuition for the data develops. The further stages of data analysis involve more rigorous approaches to searching and categorising data. However, in the initial stages, categories are identified in an intuitive way.

In order to develop such an intuition, PowerPoint presentations were used. The PowerPoint format provided a way for an initial structuring of the video data. In this way reviewing and referring back to particular sections in the video clip of a specific question was made easy and immediate. This additional flexibility of manipulating data allowed for relationships to be identified across the three interviews.

The PowerPoint presentations provided useful documentation of the process of interview questions evolving and the way the settings were changed in each interview in order to facilitate discussion, which made explicit how this affected the outcomes. The PowerPoint presentations made the first relevant connection between video data and an attempt to critically analyse and reflect on the data. A secondary role of the presentations was to be able to communicate information of the process of data analysis to other researchers in the field. The immediate nature of a video recording, accompanied by textual comments and notes could convey data more successfully and fully than a mere textual transcript.

In addition to being a documentation tool, the PowerPoint presentations provided the key means of access to critically analysing NVC (non verbal communication). Once again, the format made access to all three interviews easier and made it possible to combine taking notes alongside viewing the movie.

4.6.3. ATLAS /ti - using qualitative data analysis software

Having gained an initial intuitive feel for the data, and having generated some initial categories through viewing the video recordings several times helped me to progress towards a more rigorous method, using a more systematic tool for analysing qualitative data. Atlas/ti - a qualitative data analysis software tool was used.

MacMillan and Koeing argue for the need to make the differentiation between the use of CAQDAS (computer aided qualitative data analysis software) and what can adequately constitute qualitative data analysis. The authors describe how researchers engaged in qualitative data analysis have been misled into believing that software could substitute the need for a research methodology. They refer to this phenomenon as the 'wow factor':

'...The wow factor is reflected in an assumption that the software is the methodology, and that by simply learning to operate the program, the researcher is doing analysis.'

(MacMillan, Koeing, 2004: 180)

Furthermore, in support of this concern with the artificially expanded status of categorisation and more specifically coding, Coffey et. al. examine the treatment of grounded theory in particular within CAQDAS. They focus on the danger of specifically oversimplifying the nature of grounded theory research, and equating it exclusively with the techniques of coding and categorisation. They identify a certain danger:

'The danger that we... wish to indicate, is the unnecessarily close equation of grounded theory, coding and software. Grounded theorizing is more than coding, and software can be used to do more than code-and-retrieve textual data.'

(Coffey; Holbrook; Atkinson, 1996 : 10)

The authors believe that an unhealthy linkage has been allowed to develop between grounded theory and the use of software for the analysis of data and they see the propagator of this relationship as the ease with which the functions of coding and categorisation can be replicated through the use of CAQDAS.

A further concern associated with grounded theory in particular originates from this same close linking with CAQDAS, to the extent that the theoretical approach adopted is being dictated to researchers by the commodity of using software as a tool for analysis. MacMillan et. al. base this claim on findings from a comparative study of entries made in online discussion lists dedicated to the use of CAQDAS:

'The findings unanimously show that grounded theory is the dominant methodology for CAQDAS users - who mention it on average 30 times more frequently than sociologists as a whole.'

(MacMillan et. al., 2004: 182)

This criticism can be answered in the case of this research since grounded theory has a specific purpose within this research - that of generating theory from data in order to always use as its starting point the learners' perspective and to allow for their own agenda to prevail, rather than allowing the researcher's agenda to dominate.

Glaser and Strauss identify four stages to the constant comparative method (Cohen, 2000(d) : 151):

- comparing incidents and data that are applicable to each category[2], comparing them with previous incidents in the same category and with other data that are in the same category;
- integrating these categories and their properties;
- bounding / delimiting the theory (setting boundaries, limits for the theory);
- writing the theory.

Following, the section will make explicit the way specific aspects of grounded theory analysis have utilised features of Atlas/ti in order to achieve the objectives of this research, at each stage of the constant comparative method.

Comparison

The activity of acquiring a feel for the data and coding categories on an intuitive basis through the use of the PowerPoint format led into the more systematic activity of comparison - the first stage of data analysis identified by Glaser et. al. (Cohen, 2000: 151). The software allowed for codes to be assigned to quotations.[3] The activity of assigning codes to data was initially based on the feel developed for the data through constructing the PowerPoint presentations.

The query tool

The definition for the query tool is that it is *'used for the retrieval of coded text'* (Muhr, 2006 : 79). Glaser and Strauss synthesise this first comparison stage of the constant comparative method as:

'while coding an incident for a category, compare it with the previous incidents in the same and different groups in the same category'

(Glaser, 1967: 106).

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[2]categories are clusters of codes which summarise the collective meaning of the codes
[3] quotation - a segment from a primary document which was considered as interesting or important; usually one to which a code has been assigned

In this way the purpose of retrieval of codes is to make the comparison of new incidents to previous ones more structured and thorough and to illuminate further analysis.

The *query* tool further allowed for complex searches to be defined which specifically supported the activity of comparison. For example - a search could be defined for all quotations containing 'autonomy' **AND** 'creativity'. Such a search could prove valuable in establishing relationships between separate categories. In yielding only the shared quotations relevant to both categories, the search could be particularly illuminating in terms of identifying the specific relationship between two distinct categories such as 'autonomy' and 'creativity'. In this way the two separate categories acquired a new, shared meaning. This shared meaning would form a category of its own, which is described by Glaser & Strauss as *a property* of the initial categories:

'This constant comparison of the incidents very soon starts to generate theoretical properties of the category'

(Glaser, 1967(b) : 106)

Figure 15 illustrates how the category of 'creativity' yielded a number of properties (the *} symbol indicates 'property of').

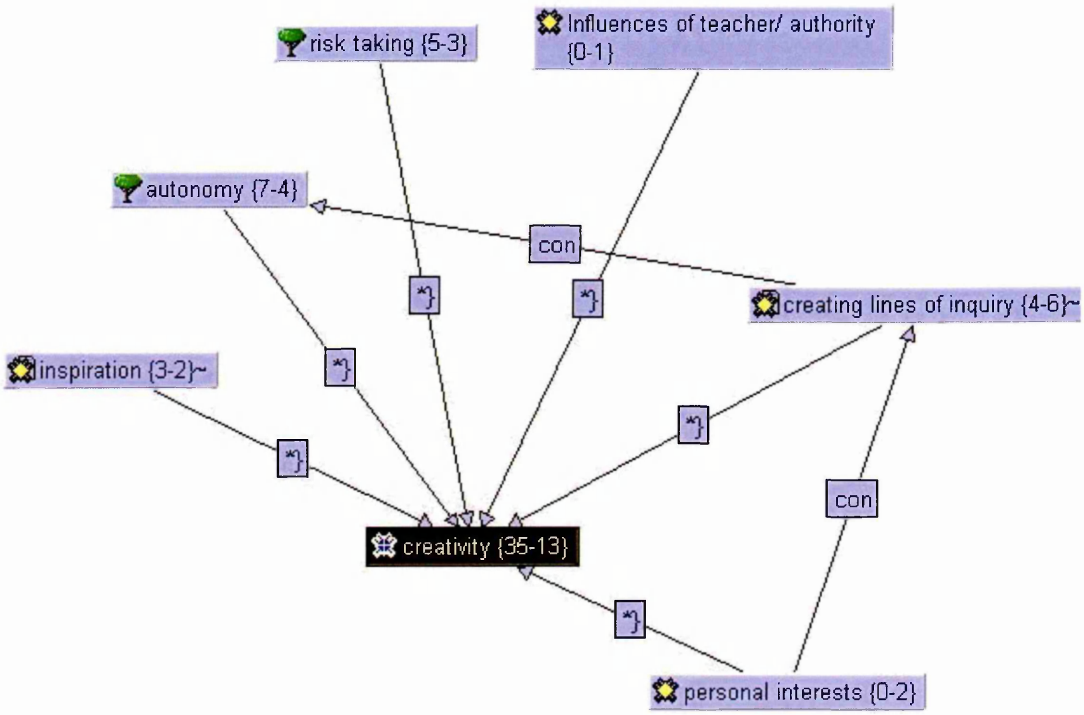

Figure 15 Creativity and its properties

Glaser and Strauss suggest that the categories abstracted from the research situation will generally be labels for phenomena, whereas those constructed by the researcher will be explanations (Glaser & Strauss, 1967(b): 107). This was certainly the case with this study, where terms such as 'creativity' and 'stimulus' were abstracted from the research situation, and thus became labels - for families of categories. The actual properties of categories within the family, identified in the process of analysis, became the explanation for the phenomenon of creativity, or of stimulus. Examples of such properties, entirely emerging from analysis, were:

- creating lines of enquiry;
- multiple representations of data;
- guidance;
- personal interests

Integration

Glaser and Strauss identify the main activity of the process of integration as moving from *'comparison of incident with incident to comparison of incidents with properties.'* (Glaser, Strauss, 1967(b) : 108) In a similar way within analysing the interview data I started by comparing incidents within the 'creativity' category. As these comparisons began to yield properties (see fig. 13), the activity gradually became concentrated on comparing incidents with properties. In this way 'creativity' stopped being actively used in the data analysis apart from in its role as a unifying category for its properties. On the other hand - a property of 'creativity' such as 'creating lines of enquiry' was compared to existing and new incidents identified in the data (see document Generating Theory, p. 10 - Autonomy feature / creating lines of enquiry). In fact 'creating lines of enquiry' became a major category which held part of the description of students' relationship with the phenomenon of 'creativity'.

Networks[4]

Apart from the query tool, networks were another technique of the ATLAS/ti software, which I used to further integrate categories and their properties in generating a unified theory. Networks helped express meaningful semantic relationships between elements. They made explicit the relationships between categories and their properties. This resulted in new meaning being created, emerging from the combined meanings of both categories and was further defined by the type of relationship identified between them.

An added functionality of the semantic networks which I found useful was naming the links or using the so called link relations (such as *is-a; property of; condition for*) in which the type of relationship between the two codes linked had to be expressed. Such link relations have been described by Glaser and Strauss, in the Grounded Theory approach as a useful technique in the construction of theory (1976(a)).

The use of semantic networks is one example of how the process of theory generation in this research adopted an approach of exploration and discovery.

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[4] network - a tool for constructing theoretical models with ATLAS/ti, a visualisation tool which helps explore conceptual structures and make them transparent

As expressed by Glaser & Strauss - exploration and discovery are implicit in the nature of Grounded Theory, which *'helps you to uncover the complex phenomena hidden in your data in an exploratory way'* (Glaser, 1976(a): 21).

Delimiting

Theoretical saturation

In delimiting the theory - setting boundaries for its scope - theoretical saturation was employed (Glaser, 1967(b): 111). A certain point was reached in the research where, whenever a new category emerged, its meaningful contribution to theory coincided with previous categories. New incidents in the data pointed to the same aspects as previous ones had done. Further, fewer and fewer new categories, which significantly contributed to the study, were identified. This stage of the data analysis process is described by Glaser and Strauss:

'After an analyst has coded incidents for the same category a number of times, he learns to see quickly whether or not the next applicable incident points to a new aspect.'

(Glaser, 1967(b): 111)

Writing

The findings of the data analysis were documented in two ways. Firstly, the memos written regarding each quotation and each category were output in a text document. These were separated in five major categories:

- collaborative learning;
- autonomy;
- task oriented problem solving learning;
- multiple representations of data;
- stimulus;

Within ATLAS/ti such major categories are termed families[5]. Families were able to capture important clusters of ideas in the way a heading does. The diagram below shows the family 'multiple representations of data' and its interrelations

[5] families - clusters of codes, memos, quotations organised into meaningful subsets

with properties and other families (see fig. 16). The properties identified for each family were output collectively in a file, which also contained all memos written regarding these properties. In this way for each family a story was constructed by using the ideas documented within the memos. The story was essentially a reflective account of how the properties interrelated, and what the implications were for student learning.

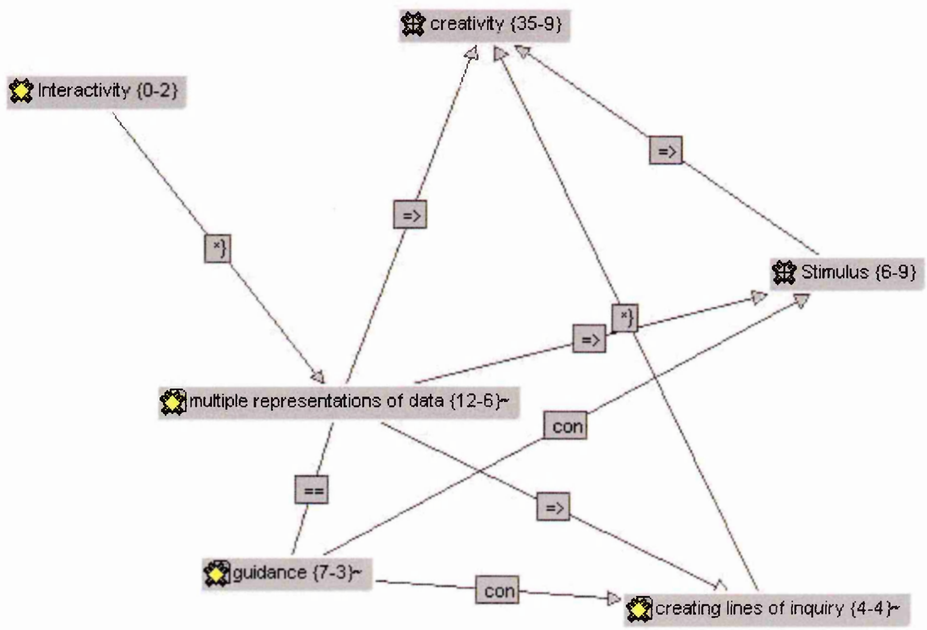


Figure 16 The family 'multiple representations of data' and its relationship with properties and other families

Since the aim of the interviews was to provide an empirical basis, which should inform the implementation of a learning environment in its design of pedagogy as well as curriculum, a list of requirements was produced which aimed to act as a requirements specification for design. Aspects of learning environment design were elucidated, such as:

- the design, structure and content of the learning material;
- the benefit of different types of feedback;
- the degree of guidance required within interactive learning to enable the learner to take control;

- the conceptual models to use for the interactions within the multimedia application;
- appropriate interface metaphors for a D&T multimedia learning application.

The following chapter describes in greater detail the major findings which data analysis of the interviews has yielded, illustrated by students' comment extracted directly from the interview transcripts.

Chapter 5. Findings of the Learning Needs Interviews

5.1. Introduction

This chapter provides an overview of the findings of the Learning Needs interviews. The findings are separated in five major categories:

- Collaborative work;
- Autonomy and creating lines of enquiry;
- Task oriented problem solving learning;
- Multiple representations of data;
- Stimulus;

Each theoretical or design principle derived is supported by evidence from the original transcripts. Parallels are drawn with the literature review, and on this basis hypotheses are established.

5.2. Collaborative work

A number of the comments made by students pointed to collaborative work as an active form of stimulus for creative thought. This led to the insight that an IMLE (Interactive Multimedia Learning Environment), which aims to support creativity should involve collaborative learning as a form of interaction, promoting discussion and joint thinking among students. This finding is supported by research literature (see section 2.1.3).

Following is a synthesis of the aspects of creativity which bear a relationship to the collaborative learning experience.

5.2.1. Cognition and verbalising thoughts

Within group work activities students are encouraged to express their thinking verbally. Thoughts unfold in the act of speaking and develop in the course of discussion. The following comments indicate that thinking processes engendered in dialogue are directly related to creative thinking:

Researcher: *Have you ever had any ideas from such discussions?*

J: *What - in a group?*

Group: *Yes definitely.*

J: *We had to design some way of carrying food and drink in a restaurant and we all talked about it, and then we went away and designed and you could see that everyone had got ideas from what everyone else had been saying. It is a lot easier to do those designs after you've talked rather than just sit down by yourself.*

It is clear from this instance that dialogue has led to and influenced thinking in the creative process of designing and facilitated the generation of ideas. It is a valid conclusion therefore that verbally expressing thoughts can have the positive effect of clarifying ideas in the subject of D&T.

Another positive contribution of collaborative learning is the opportunity to benefit from different perspectives on the topic of discussion. This is particularly valuable in the context of activities such as idea generation and idea exchange as the following section makes clear.

5.2.2. Different perspectives and their value as a source of feedback

Inevitably, people perceive things in different ways. In terms of creativity such variations can be very productive – they have the capacity to form the basis for unusual, original solutions. In working collaboratively, students bring in a variety of different perspectives on the subject discussed, usually drawing on their personal experiences (Boyle, 1997(a)). As expressed by the interviewees, it is this variety of perspectives, which they see as the most valuable aspect of collaborative work. Following is one of the instances taken from the interview data, which supports this suggestion:

Student: *Same with asking questions - if you ask your mate it might give you something you haven't thought of, that may be you might want to consider when designing something.*

The cognitive process which is implicated within the exchange and sharing of ideas, is experiential learning - within such discussions students generally draw on their previous experiences and knowledge, in trying to resolve a common goal. Sternberg points to personal experiences as one of the two major sources of influence on creative practice, the second being other people's work (Sternberg, 1988 : 169). He implies that a situation in which everyone contributes ideas coming from personal experience applies a process of experiential learning, which can be potentially creative in the collective ideas it yields. We can therefore look to collaborative learning as providing a suitable framework which can accommodate experiential learning successfully. This form of experiential learning is creative or inductive of creative thought, since it is grounded in the learner's personal experiences. The potential of experiential learning to inspire creativity is reinforced further by the conditions in which it occurs – students' comments indicated that such idea exchange usually happens within brainstorming group work activities, which are focused on the task of generating ideas.

5.2.3. Feedback

Further than a way of clarifying thoughts and bringing in different perspectives on a given topic, collaborative work also provides a form of feedback to students. The informal discussion which students engage in when working together tends to bring out more honest and uninhibited comments and thoughts. Rather than teacher or authority led, the discussion becomes student instigated and directed. Such a student-led, active way of learning leads us back to Hennessey and Amabile's ideas of self-esteem and intrinsic motivation as necessary factors for creativity - in expressing themselves freely students become autonomous (Hennessey & Amabile, 1988). Further, no authority figure is present in their discussion with each other, which means students themselves have the opportunity to become the authority. In giving feedback to each other, learners reaffirm each others' opinions and ideas as valid, thus building up their self-esteem and taking a firm step towards becoming autonomous, free thinking, independent learners. The following comment illustrates that students themselves see that the feedback, which they receive in collaborative work from fellow students has a unique value:

C: *You are more likely to get bad criticism (from other students) but it's good in a way. And you can always go to them for aesthetic reasons because they are of the same age and sometimes into the same kind of stuff. So if you make* *a clock that looks like it's from 1930s' and say: 'What do you think of this?' they'd go: 'Well it's pretty ugly actually'. You are going to get an honest answer off your friends. It's not like if you go up to a complete stranger and they try to be polite to you.*

R: *I've found asking questions quite useful - just with one or two friends. If I came up with a problem I couldn't solve on my own - just get one person you can talk about it with and see if he can help.*

C: *Sometimes people who can't be bothered they'd just say - yes, it's fine, but there might be someone there who thinks: 'well may be if you change it like this, if you swapped that round or something' it could make you think - yes that could be a good idea.*

The importance of such learner-to-learner dialogue led in the absence of a teacher or an authority figure is emphasised in the work of Vass (2002), who sees the friendship pair as the basic unit for the development of creative thought, precisely because of the possibility of humour, spontaneity and free expression to become part of the learning interactions.

5.2.4. The role of the computer

So far, evidence points to the fact that learning material, which aims to enhance creativity in students, needs to be designed to realise autonomy and provide opportunities for experiential learning as well as feedback. The way this can be achieved is to design tasks and learning experiences to involve more than one learner at a time, thus encouraging dialogue and discussion amongst learners wherever possible. In this sense, it seems that an environment, which affords learning for the subject of D&T, needs to be a collaborative learning environment where the act of discussion and idea exchange is promoted as a central activity.

Since the interview data emphasises the value of dialogue amongst learners specifically, this has implications for the role of the computer within these interactions. The role of the computer in this case can be seen as one of a dialogue partner:

'...the system acts more like a partner than a machine that simply obeys orders.'

(Preece, Rogers and Sharp, 2002(c): 44)

The importance of dialogue defines the conceptual model for the interaction as conversing (Preece et. al., 2002(c): 44). The computer's role is to organise the experience for the learner, but at the same time allow for and encourage dialogue to develop among learners. In this sense, the emphasis is on the interactions, which take place among students, not between computer and student. That is where the really interesting dialogue will occur. Dialogue with the computer, or any interaction with the computer, needs to serve the purpose of stimulating discussions among students, providing an environment where they are encouraged to talk, verbalise ideas, discuss. The machine thus plays the role of a trigger for dialogue and a meeting point for discussion. It organises the experience for the learner, providing a structure and a content around which dialogue can be generated. Once the experience has been organised in this way, it would be the learners' task in constructing knowledge to contribute with original and versatile thoughts.

5.2.5. Guideline: Guidance and experiential learning

Research literature has identified the benefits of experiential learning to creativity. Furthermore - interview data indicates that it is a learning strategy, which D&T students naturally adopt within collaborative work activities such as brainstorming or informal discussions. The task design and content of an IMLE should therefore be targeted at encouraging students to apply experiential learning. The task or activity should aim to encourage the learner to construct an understanding of a concept in design, through engaging in a practical, possibly problem solving, task. The most appropriate framework for this would be a task which affords collaborative dialogue and discussion.

5.2.6. Guideline: Guidance and feedback

This idea of the computer posing guiding questions reinforces the conceptual model of conversing, and the role of the computer as a dialogue partner (Preece et. al., 2002(c)). Unlike the examples described by Preece et. al. however, the context in which this model of conversing is used will not be so much searching for information or information retrieval, but triggering further discussion on a topic. Asking a question will have as its purpose to trigger and generate discussion amongst students, rather than to direct a search for explicit information.

Several issues emerge here. If the system only poses a question and leaves the rest - meaning making - to the learners, would learners be sufficiently motivated to carry out a discussion on the question amongst themselves? This question makes it necessary to consider mechanisms for interacting with the system, which stimulate learner engagement. From the point of view of the interaction style used, direct manipulation is known as the style of interaction, which is most closely related to producing user excitement (Shneiderman, 1998). Within digital media it is also the style which is most characteristic of computer games (see section 2.2). Thus it is desirable to consider game based learning as one of the viable tools for supporting a learning system based on open-ended enquiry.

Feedback mechanisms, which act as a response to learners' actions, can also have the desired stimulating effect. Feedback in this case is seen as a way of propelling interaction and encouraging the development of reflective though. According to Lansdale *'people learn by relating consequences to their actions'* (Lansdale, 1995: 117). Therefore our task is to design the consequence according to learners' actions, and further - to inform future actions. This is how we can ensure learning has taken place.

5.2.7. Summary - collaborative work

- The different perspectives which students bring into a discussion encourage the process of seeing things from a different point of view and form a natural condition for creativity in the D&T learner. Therefore a learning environment will benefit the creative learner considerably if it offers a possibility for these different perspectives on a topic to be expressed.

- The learning strategy, which is implicated within this exchange of ideas, is experiential learning - in discussion students generally draw on their previous experiences and knowledge, while trying to resolve a common problem. This points towards a social constructivist theoretical model for an IMLE, and an emphasis on collaborative problem solving.

- The informal discussion which students engage in when working together brings out honest and uninhibited comments and thoughts. This is a valuable form of feedback which makes the learners more autonomous, independent and free-thinking. It also minimises the need for an authority figure and once again - reasserts autonomy.

- The computer's role is to organise the experience for the learner, and allow for and encourage dialogue to develop amongst learners. In this sense, the emphasis should be on the interactions, which take place among students rather than between teacher and student.

- The system should encourage the construction of knowledge not the acquisition of knowledge. It will do this by offering an opportunity to the learner for discovery and exploration rather than presenting knowledge as a given, in its final form.

- The system should avoid offering 'yes' and 'no' answers as feedback to the learner, since straight denial can be detrimental to creativity. An approach to open ended questions as a form of learning aid necessitates a strong form of stimulus to engage the learner's attention sufficiently in order for them to become involved in in-depth exploration. Such stimulus can be provided by using elements and strategies characteristic of game based learning.

The following section looks at the issue of autonomy, aiming to establish students' perceptions and learning needs in this regard.

5.3. Autonomy and creating lines of enquiry

5.3.1. Concept-oriented content / diminished teacher responsibility

Within the focus group interviews, students' comments displayed lack of confidence in taking a project into their own hands. It appears that students rely on their teachers to tell them where to look for inspiration. They are not prepared to take on a project and steer it creatively in the direction in which they, as individual learners and future professionals think is best. This is understandable, since creative drive, direction and autonomy take a lifetime to master. The question for education is how can students be provided with the opportunity to develop their autonomy and confidence through engaging in project work - how to put the creative drive back into students' hands?

Interview data has suggested that one way to achieve this is to provide students with the tools for creative enquiry. Following is a comment made by a student at the stage of identifying a self-directed project, which illustrates the importance of students being able to create their own lines of enquiry:

Researcher: *Which stage would you say is the hardest?*
Student: *Specification. It's all right if you are being given a specification but with this project we are totally on our own. We have to write our own brief. You've been waiting since year 7 for your own project and then you are totally blank, you can't think of anything to do. So it's quite hard to think of something to do but you have to also make it with a difference. There's no point in just making a table because it has already been done before. You have to think of products that you can change for the better and it's sometimes really hard. Some of us don't even have an idea of what subject we are going to do yet.*

If students learn to construct their own questions and inquiries, to reflect on their own work and make confident decisions about their progress, then they would become more capable of driving and managing a project on their own successfully – in these terms creating lines of enquiry is a necessary condition for autonomy.

In terms of learning theory, seeing a learning environment as a set of cognitive tools is an idea which belongs to the cognitive constructivist perspective. Papert's notion of microworlds explains how a learning environment can provide all the tools necessary for the learner to construct meaning and knowledge through exploring and interacting with the system (Papert, 1980(b)).

The key outcome of using the learning environment as a rich set of cognitive tools is the ability of D&T students to be able to create their own lines of enquiry. The ability to create lines of enquiry is a prerequisite for creativity - if students do not explore a wide scope of issues they would fail to yield creative solutions to their subject area.

5.3.2. Diminishing teachers' responsibility

The difficulties of finding a subject to design for culminate in lack of creative drive. If the student speaking in the previous comment was aware of a range of general design issues, then ideas on various possible lines of enquiry would be easier to think of and the role of the teacher in shaping the direction for project work would be transferred to the student. In reality, when it comes to choosing a subject for project work, especially at the stage of A level – i.e. a major self-directed project - students rely almost exclusively on their teacher. The following comment illustrates this point (see Appendix 3):

Researcher: *Is anyone doing something that resolves a need, improves people's lives?*

D: *Mine's a bit like that. It's a portable polling station for third world countries. It's made out of cardboard - it folds down. It's made out of recyclable materials.*

Researcher: *How did you decide to do this?*

D: *Mr X (teacher) suggested it to me.*

Researcher: *Do you like the idea of doing something to do with eco design?*

D: *It's quite interesting - it's resolving a problem that's affecting people.*

Researcher: *Anyone else?*

P: *I'm doing a bin to help people recycle. People can't be bothered to recycle so I'm making a bin that makes it easier.*

Researcher: *Did that come from your teachers as well?*

P: *Yes a little bit.*

Interview data shows that most project ideas which tackle issues in design outside of students' personal experiences, are likely to have been suggested by the teacher. Lack of autonomy is apparent wherever students have not been capable to create their own lines of enquiry. Furthermore, if the project has been suggested by a teacher, it is less likely that the student would feel it is their own idea and the motivation factor is in danger of being reduced if not completely lost (see section 2.1.4). One of the ways of addressing this issue is to diminish the responsibility of the teacher in their capacity of suggesting design ideas to explore.

The following comment by a student is another instance of how the intervention of an authority figure has had a negative effect on the student's creative drive:

M: *I've had a few ideas but they haven't really been accepted. I was going to make a landscape feature of may be various uses. But that could be sold for job production if it was specifically for certain people who might need it - like a landscape model of a certain area. But there is not much of a market and you couldn't really mass-produce it - that was the problem and if you were going to do it, it would end up as something that was just vac-formed into a sheet of plastic, which isn't really what I had in mind. So I had to scrap that idea.*

From M's description it appears that he has given up on his idea or been discouraged because *'it hasn't been accepted'*. The idea doesn't seem to fit the boundaries of schoolwork. The student seems to have abandoned the idea, rather than finding a way to make it workable. In this instance, it seems that authority has had a negative effect on the creative drive of the individual. Even though M had engaged in some interesting initial research (visiting shops, talking to shop assistants) and had potentially good sources of stimulus, the stimulus was not supported by the approval of authority and the creative drive had therefore been suppressed.

It appears that students are in need of their ideas being supported by authority, in order to further pursue these ideas. This need is a symptom of learners not being able to realise their autonomy and being overly dependent on the approval of authority. This further points to the need to provide an adequate supplement to the role of the teacher as identifying contexts to explore within students' project work.

The third element in the interaction, the role of the computer, also needs to be considered. The computer can be seen as providing guidance in the form of semi-structured, open-ended questions, suggesting possible directions for exploration but not imposing a specific direction, thus allowing the learner to feel in control of the choices they are making and ultimately having a positive effect on learner autonomy.

The hypothesis I am positing in suggesting such a role for the computer is that the computer is not envisaged as an authority figure with students and would therefore more naturally allow them to develop the feeling of ownership over the ideas arrived at. As Adams (1973) maintains – a computer based learning environment, specifically one based on the premise of games, provides a non-authoritarian environment in which learners can act without fear of censure. This kind of environment would also be beneficial to supporting risk taking by the learner - a necessary factor for creativity (Kimbell, 2000(a)). If the learner is able to take risks and experiment in an environment, which does not penalise, they will become more confident and hopefully carry this attitude in their actual work.

5.3.3. Concept oriented content

While the findings so far elicited have strongly indicated the need to diminish the role of the teacher as suggesting project ideas, this poses a further issue. From students' comments it appears that projects which originate from the students' own interest, are somewhat limited in scope. The following are some examples of projects, which students have chosen themselves:

C: *I think it's just identifying a problem that you come across yourself in everyday life. For example, my project is a new design for a cinema seat. Because I go to the cinema quite often and I found it a problem with the storage of your popcorn and drinks so I'm trying to find a solution really.*

P: *You do something you need yourself that applies to everyone else...I'm doing a unit for a PlayStation 2 - to store it because mine's getting knackered - it keeps getting trodden on...*

J: *I'm doing a display case for collectables and figurines.*

In the comparison with student-generated ideas those suggested by their teacher seem to consider broader issues in designing - such as sustainability and eco-design. This suggests that the teacher is in some ways being used by students as a resource of issues, which can be explored within design work. This leads to the idea that a learning resource, which aims to support independent thought, would benefit the learner most if it involves content which is concept oriented. As explored in the previous section on *Diminishing Teacher's responsibility* it is because a computer based learning environment is naturally perceived as non-authoritarian that the learner would be facilitated in gaining ownership of the idea.

The content of the multimedia application needs to have as a focus a broad range of design issues and concepts, of which eco design and sustainability are a good example. The work of Practical Action (Practical Action – Education) and the Sustainable Design Award (Sustainable Design Award Online) are examples of how the topic is already becoming part of the experience of learning in D&T at A level, through the use of a web-based medium. Further, such complex issues discussed in the context of a specific design task will aim to help learners acquire a thinking mechanism, a template, which they can apply when constructing their own lines of enquiry within design work.

5.3.4. Guideline - Concept oriented context

On the basis of students' comments as well as on the basis of previous work on designing learning materials for A level D&T, two main elements are essential to make concept oriented content work in a learning environment:

- A series of case studies based on universal concepts in design;
- A task oriented problem-solving environment;

Learners can be set a specific task or problem to work on. Most generally – this would be a task to do with coming up with ideas for designing a product. This will be supported by series of case studies based on design issues, possibly sustainability or eco design. These case studies could be used by learners to establish analogous relations to facilitate problem solving. Learners can be shown case studies relevant to the problem they are tackling. Having applied the relationship between concept and case study once, within a multimedia learning environment, will make it more likely that the instance of using this analogy will stay in the learner's memory and they would be able to apply it in future to their own design work. The multimedia task in this way will aim to create an experience for the learner, which will in the long term stay in their memory and influence the creative thinking process in their future design work.

5.3.5. Guideline - System instigated dialogue as guidance

The process of students constructing their own lines of enquiry should be supported by giving learners guidance in constructing questions which to investigate. System-instigated guidance can help steer the process of interaction in directions which can be valuable in encouraging the learner to think more deeply about the subject, thus creating lines of enquiry. The system can achieve this by well-timed, open-ended questions, as well as suggestions about tasks to engage in. The system will thus aim to help the learner generate well-informed and directed enquiries.

It was established that the most appropriate conceptual model for interaction between system and learners is conversing (Preece, 2002(c): 44), the emphasis in dialogue being on learner-to-learner dialogues and the role of the computer within this - that of an organiser of the experience as well as a stimulus for the interaction. This conceptual model is valuable both in the way feedback is provided for the learner and in aiding the process of learners creating their own lines of enquiry. As was said earlier the design of the learning interactions needs to allow for and encourage students to engage in dialogue and verbalise thoughts. This form of feedback or guidance from the system places the emphasis on dialogue between learners. In this way learners are placed in a situation where they primarily rely on each other for feedback. Such feedback from each other will aim to provide an adequate substitute for the now diminished role of the teacher as instructor.

The challenge for the design of the learning environment is to design the content and learning interactions in a way which would provide sufficient information, stimulus and feedback to the learner in order to encourage them to engage in useful dialogue and result in them creating their own lines of enquiry, in dialogue with each other.

5.3.6. Summary – concept oriented content

- Students struggle to find a context to work within when faced with a self-directed project. They need to become aware of the wider issues and implications of designing, such as the increasing need for products to be eco friendly.

- Learners are dependent on the teacher in decision-making and this stifles their creative potential. The role of the teacher as suggesting contexts to work within needs to be diminished in order to allow the learner to develop as an autonomous thinker.

- A learning resource, which aims to support independent thought needs to involve content which is concept oriented. This means introducing the complex issues which place the design discipline in context will aim to help learners acquire a thinking mechanism (cognitive strategy) which they can apply when constructing their own lines of enquiry within design work. Case studies and a problem-solving environment are necessary to support this process.

- The interaction with the computer is seen as supplementing the role of the teacher in suggesting contexts to work within to the student. It is expected that a computer system would be perceived as providing a non-authoritarian environment where autonomy is allowed to develop in the learner.

- Where dialogue and feedback are concerned the emphasis needs to fall on learner-to-leaner interactions. The computer's role within this would be to provide guidance and content in a non-intrusive way such as would help the learner in generating well-informed and directed enquiries.

These guidelines regarding the value of collaboration to D&T formed the basis for the research questions posed in chapter 6, in particular those referring to the use of dialogue and idea generation through dialogue (section 6.3.1, Structuring learning content and learning interactions).

5.4. Experiential learning and problem solving

5.4.1. Experiential learning

Experiential learning – using one's previous knowledge and experiences in trying to understand concepts, solve problems etc. - encourages generative thought (Weisberg, 1988: 153)

Brainstorming as a way of generating ideas common to the D&T learning experience incorporates within it the idea of experiential learning – most contributions, which students make in terms of ideas are based on what they have previously experienced. This was apparent within task-related questions in the interviews - students displayed the ability to construct complex ideas and make original connections on the basis of previous knowledge and experience. They naturally adopted this style of thinking when asked to analyse existing products in *Q4 Inspiration* (see Appendices 1 to 3, Question 4). The following comments illustrate this point:

Discussing the Bouloum chair

B: *The human body*

C: *Speaks for itself – there can't be anything comfier than sitting down on something that's sitting down.*

M: *Inspiration comes from somebody who slouches on a couch – people rarely sit upright in a sofa. If you want to relax you tend to slouch down- stretch your legs forward, which is what this has got – head tilts back slightly…*

In this instance, the students' analysis of the chair's functionality was based on previous experiences of sitting in chairs, and possibly – on observing how others sit in chairs. The kind of knowledge, which students constructed, was based not on knowledge explicitly taught or memorised but on practical, everyday life experience. A further factor needs to be considered to turn this experiential knowledge into a process of active knowledge construction. Knowledge construction is more likely to emerge in the interaction of the life experiences, which several students bring into the discussion of a topic. Once again, it is in discussion and verbalising thoughts that ideas are born.

Figure 17 The Bouloum chair used as a basis for students' discussion.

5.4.2. Problem solving

Problem solving is what the subject of D&T requires of students and accordingly it is what D&T students adopt as a natural learning strategy. Within the focus group interviews, questions, which were task-oriented promoted discussion among students and contributed to the development of complex thoughts and ideas. Across the groups interviewed, students were more motivated when working on a task towards a common goal. This was especially apparent with question 2 The Design Stages (see Appendix 3, Question 2). The degree of engagement with the task, which students displayed was high enough to suggest that they must have been partly intrinsically motivated. Indications that their motivation was intrinsic were the students' body language, conveying active participation. This raises the question - if it was not the subject matter of the question, which engaged them, what did? I would argue that the answer lies almost entirely in the way the question was posed - as a task. It is therefore natural to conclude that learning material, which aims to engage D&T students in active participation needs to adopt a task oriented problem-solving format.

To summarise, experiential learning and problem solving are closely interrelated. Within the subject of D&T experiential learning and problem solving are learning strategies which students naturally adopt. Task orientated learning is the optimum environment for problem solving and the one, which is most likely to encourage students towards active participation. The process of creative thinking as problem solving suggests a constructivist approach to generating a teaching strategy within a learning environment. Constructivism supports the idea of using students' natural learning strategies as a starting point on which new knowledge and understanding are gradually built (Boyle, 1997(c): 49; Laurillard, 2002(e): 67). An IMLE, which supports the D&T learner's natural learning strategies and affords creativity, needs to apply a problem solving approach and promote experiential learning.

5.4.3. The role of the computer

The following features have been identified as necessary for an IMLE to enhance learning and creativity in D&T students:

- A task oriented problem solving environment;
- An environment which encourages collaborative work;
- An environment which encourages experiential learning;
- An environment in which students work together as a group towards the achievement of a common goal;
- Feedback provision upon students' actions to propel the interactions further.

The role of the computer in this case is seen as providing a task-oriented problem-solving environment within which learners can be encouraged to interact, converse, reflect and generate ideas. The environment can emulate a game like setting, where teamwork and adopting roles is supported. The style of interaction, which would best support such functions, is direct manipulation.

5.4.4. Direct manipulation

One of the characteristics of direct manipulation is the immediate feedback on users' actions. Such immediate feedback propels the interactions further. As Shneiderman argues, the rapid response feature of direct manipulation *'produces a satisfying sense of power and speed'* (Shneiderman, 1998 : 203), which enhances the learner's feeling of being in control. As Lansdale points out being in control is an essential condition for learning (Lansdale, Ormerod, 1995: 113) – before the user is capable of learning from their interactions with the computer, they will have to become confident in manipulating the system. In this respect, direct manipulation offers the optimum solution – immediate feedback, usually visual, allows the user to feel in control. In this way, direct manipulation environments have the potential for implementing the constructivist notions of an active learner and learner-led interactions.

Principles of direct manipulation

Direct manipulation uses pictorial representations of content, usually in the form of signs or icons. Research literature argues for the value of such representations which utilise the capability of the human brain to scan a large number of icons in a short amount of time, making use of peripheral vision, as opposed to text, which takes a greater amount of time and cognitive effort to interpret (Lansdale, Ormerod, 1995: 199; Leibniz in Shneiderman, 1998: 185).

The immediacy of signs and their effect of reducing cognitive load add an element of pleasure to human computer interactions, bringing them closer to the game like experience. As section 2.2.2 discussed the most significant advantage of using the game-like experience in learning is the increased level of motivation to the user. Therefore, there is a link between direct manipulation and intrinsic motivation.

As it is based on visual representations, direct manipulation places less emphasis on being skilful with the tool of interaction. The user does not need to be an expert in how the interface functions in order to be able to use it. Thus the tool of interaction becomes *'invisible'* and the user is able to *'apply intellect directly to the task'* (Shneiderman, 1998: 202). One notable effect of making the tool of interaction 'invisible' is that the sense of direct involvement with the task is heightened and the gap between action and reflection upon action is breached (Hutchins in Shneiderman, 1998: 203). In these terms direct manipulation can be seen as a valid way of approaching the issues around what was referred to as Judging Value in the All Our Futures report:

'Helping young people to understand and manage this interaction between generative and evaluative thinking is a pivotal task of creative education.'
(NACCCE, 1999: 31)

In bridging the gap between action and reflection, direct manipulation encourages evaluative thinking alongside the generative in students.

We can start to see therefore that direct manipulation is desirable as a style of interaction where problem solving is required. Its stimulating effect on the user is a further advantage. Both of these functions are essential in a learning environment, which aims to enhance learning and creativity in the D&T learner.

5.4.5. Summary – experiential learning and problem solving

- Experiential learning is D&T students' natural learning strategy. Problem solving, creativity, and experiential learning are closely interlinked. The system needs to provide a task orientated / problem solving environment, in order to support students' natural learning patterns;
- The role of the computer is seen as providing a task-oriented problem-solving environment within which learners can be encouraged to interact, converse, reflect, and generate ideas. This can be done by the environment emulating a game like setting, where collaboration is supported. The style of interaction, which would best support such a setting is direct manipulation;
- As a style of interaction direct manipulation has the capacity to enhance stimulus in the learner - which is one of the essential conditions for creative development;
- Using visual representations of concepts is recommended - in this way the tool of interaction becomes *'invisible'* and the user is able to *'apply intellect directly to the task'* (Shneiderman, 1998: 202). In bridging the gap between action and reflection, direct manipulation encourages reflective thinking in students.

Research questions exploring the value of experiential learning are posed in Chapter 6 (section 6.3.1, Structuring learning content and learning interactions). The ideas emerging from the Learning Needs interviews regarding experiential learning are embedded within these research questions.

5.5. Multiple representations of data

The Learning Needs interviews placed a necessary focus on multiple representations of data (MRD). A primary advantage of MRD is their capacity to enhance stimulus in the learner. MRD are one of the most powerful potential benefits of using multimedia to deliver learning material – they stimulate and engage the learner's cognitive processing.

Within the focus group interviews, this research has looked for evidence of how students utilise the variety of stimuli available to them in learning D&T. It was important to place the emphasis on students' point of view of the benefits and shortcomings of learning resources, which utilised MRD, rather than to focus on the way the resources were intended to bring benefits from teachers' point of view. This research has further looked for evidence of where these multiple representations of data were lacking in students' learning aids as well as where they could be most beneficial. The following excerpt illustrates this point:

Researcher: *When starting a new project how do you choose a topic for your design? Where do you look for information?*

J: *On the internet.*

Group: *Existing products*

R: *Materials*

Researcher: *So if you go to the internet and type 'materials' would that give you an adequate search?*

J: *No, we type 'plastic toys' and see what it's made out of; then go back and look up the materials we found out.*

R: *Manufacturing techniques*

Researcher: *Where would you look for that?*

R: *Probably on the Internet again... Find out how the existing products were made and do research into those.*

In this discussion the relationship between the information, which students found out and the source they used to look for it, is obvious. It is because they used the internet that they ended up with research, yielding very narrowly practical types of information - manufacturing techniques, some materials.

While the internet uses multiple representations of data, it often uses those to the effect of marketing a product rather than educating. Students are drawn to it as a source because it is immediate in the results it yields. The drawback of this approach is that it is unlikely to lead to research, which is interesting, in-depth, challenges the learner to ask questions, or results in deep thought. Such research 'on the internet' may yield superficial results rather than forming interesting enquiries.

Internet searches can only be beneficial if after having initially established a line of enquiry, the learner expands and develops this in the course of searching for information. The problem is that students are drawn into searching before they have a clear and coherent idea of what they are searching for. This is why it is important that guidance from the system and dialogue between learners as a way of forming lines of enquiry should be combined, with the aim of gradually building on and developing their initial line of enquiry.

The learner has to be able to interact with the learning material - learners have to construct meaning rather than be 'given' ready-made meaning. Learners have to be encouraged to look for and form questions rather than look for somebody else's answers. In this way, while MRD such as a combination of digital media can be a powerful tool for constructing lines of enquiry, it is necessary to place these media within a pedagogic structure which would provide sufficient guidance for learners to then proceed to forming their own lines of enquiry.

The following example illustrates the educational potential of MRD. Students were given a series of three images of products and were asked to analyse those in terms of the source of inspiration used. In discussing the *Kantarelli vases* the following dialogue occurred (see Appendix 3, Question 4):

Researcher: *Where did the inspiration come from?*
Group: *Looks like a flower.*
Researcher: *What do you call that - inspiration from flowers?*
B: *It's a vase - put flowers in it.*
J: *Ironic in a way I suppose.*
Researcher: What's ironic?
J: *It's designed to hold flowers and it's a flower itself.*

Researcher: *Have you used that technique before - where you design something, which looks like the thing it's supposed to be functioning for.*

(Group are silent)

J: *I haven't personally but there are products on the market that are like that such as mini-fridges shaped like Coca Cola cans designed to hold drinks.*

Researcher: *Have you heard of the idea of form follows function?*

(Group are silent)

S: *No*

B: *Yes*

Researcher: *Is any of these form follows function?*

B: *I suppose yes - human sitting in a chair - it's a human; flower goes in a vase - it's a flower.*

J: *It's a lot more about form (the vase)*

C: *It is a lot more about form and being aesthetically pleasing - I mean you can just get a mug and put flowers in it if you wanted to and you can still call it a vase. But here the design is concentrated a lot more on how it looks and how he or she (the designer) thinks the consumer desires in a way.*

This is an example of how a very small amount of visual stimulus was able to trigger reflexive thought. Students were encouraged to speak by being given several guiding questions. This minimal amount of input proved crucial to triggering reflective thought in students. The implication within this is that MRD need to be supported by guiding questions, which would help the learner construct their own lines of enquiry. Such guiding questions need not be definitive. Since their purpose is to give directions, it is sufficient for the guidance to be in the form of semi-structured questions. Consequently, if the stimulus is present to support these questions, it would be relatively easy for the student to come up with a variety of ideas and thoughts about the subject discussed.

Targeting the learning material - stimulus

Another point to consider regarding the use of media as stimulating learning is the relevance of the material to the student. The following is an example of how the curriculum has tried to integrate MRD with the aim of stimulating students, however it has failed to grasp their interest and imagination:

Researcher: *Do you use video?*

B: *Last year we watched one about manufacture of car bodies, washing machines.*

J: *Manufacturing processes.*

S: *It was pretty useless.*

B: *Came up in the exam.*

Researcher: *Why is it useless?*

C: *I think the videos that we watch need to be more up to date. Because a lot of them are from the mid 80s and looking at design back then, whereas since the computer - in the last decade everything has moved on so quickly.*

Researcher: *Have you ever used it for your own design work? To record work?*

Group: *No not really.*

Students' comments indicate that they saw the relevance of the film only from the point of view of achieving the results, which were expected of them:

Student: *'it came up in the exam'.*

They failed to see the relevance to their own work however, or any relevance outside the immediate benefit it had to teach them what they needed to know for the upcoming exam. In other words – students' motivation in watching the film was entirely extrinsic. Such attitudes to learning are contrary to creative practice (Hennessey & Amabile, 1988), and ultimately unproductive for learning.

It is therefore important to emphasise that a condition for MRD to have educational potential is for them to be supported by stimulus, which would be intrinsically motivating to the learner. This can be achieved by targeting the learner's interests, keeping the material up to date and as immediately relevant to students' own design work as possible – in other words the learner should be able to see the relevance of the learning material to their own work.

To sum up MRD are not beneficial per se. To have educational value they have to be conceived as tools for learning, and become part of a pedagogical structure. Further, to make MRD useful tools for learning, two factors have to be addressed. Firstly, the information needs to be relevant to the learner. It needs to be presented to the learner within a context they can understand and relate to. A condition for the material to be stimulating is that it has to be kept up to date, and as immediately relevant to students' own design work as possible. Secondly, it needs to be supported by a certain amount of guidance, such as would encourage and predispose the learner to keep thinking about what they see and actively construct meaning from it.

5.5.1. Summary – multiple representations of data

- The learner has to be able to interact with the learning material - learners have to be encouraged to construct meaning rather than be 'given' ready-made meaning;
- Learners have to be encouraged to look for and form questions rather than look for somebody else's answers;
- Provide stimulus, which is intrinsically motivating to students by targeting the learner's interests, keeping the material up to date and as immediately relevant to students' own design work as possible;
- The use of multiple representations of data is not always beneficial to the learner – to have educational value they have to be conceived as tools for learning, rather than an end in themselves.

The research questions drawn in Chapter 6 make use of these guidelines on multiple representations of data in order to explore learners' motivation, and the factors in a multimedia learning environment which support this motivation (section 6.3.1, Affective factors which influence learner creativity).

5.6. Stimulus and intrinsic motivation

Stimulus naturally arises from learners' personal interests. If the topic fails to create any form of personal interest in the learner, there is little possibility of creative output on their side. This kind of personally relevant stimulus enhances the learner's intrinsic motivation (see fig. 18).

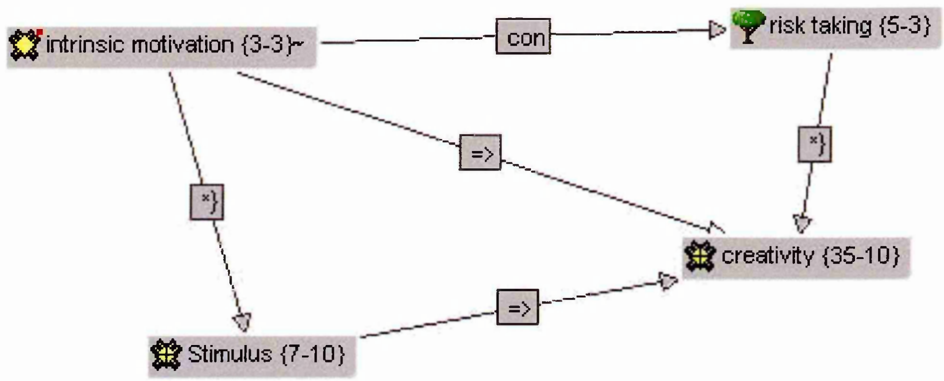


Figure 18 The relationship between stimulus and intrinsic motivation (legend: con: condition for; =>:results in; *}:property of)

The following is a comment by a student, which illustrates the necessity for project work to be personally relevant to the learner:

M: *I wouldn't do it (referring to another learner's project idea). I find it boring and therefore I find it hard to work with. Because it doesn't personally interest me I would avoid it in order to do something that would interest me. If I was interested in whatever I was designing I would be keen to get to work on it. Therefore, I'd get better ideas for it. As I'm not an avid camper I couldn't really think of many things that you could change about a barbecue.*

This comment is a good example of how lack of stimulus can result in lack of creative drive. As M's comments indicate – he is incapable of thinking of many things that can be changed or improved on in camping equipment. Also in his own words: if he found the topic boring, he would find it hard to have ideas. Students' ideas for projects usually come from their personal interests - hobbies, etc. If a topic does not interest them, they find it hard to have ideas and be creative about it.

Within a multimedia learning experience, tasks, which are set to the learner, need to draw on the learners' personal interests. The tasks need to be targeted in a way, which will inspire interest and involvement. The type of project the students are interested in for example can be extracted from the projects A level students have chosen for themselves over the years.

5.6.1. Intrinsic motivation and the creative individual

Learners will be intrinsically motivated when they are involved in tasks, which explicitly require them to display creative ability. In a sense the learner should be made aware that they are being asked to display originality of thought. This knowledge will in itself act as a stimulus to the learner, who generally likes to think of themselves as creative individuals.

In the following comment learners are discussing Question 3 which asks them to choose from three different ideas, varying in the degree of originality of thought and the degree of risk taking which they required. It was interesting to notice that across all three interviews learners were more drawn to Idea 3, which offered the most potential for innovative thinking, even though it was the riskiest. The arguments they gave for choosing the idea were related to the students wanting to do something different. They were inspired by the idea of being original in their thinking (see Appendix 1, Question 3):

J: *Three (meaning Idea 3)*

Group: *(agree)*

Researcher: *Definitely - all of you - three?*

Group: *Yeah*

Researcher: *Why?*

J: *Because it is innovative and it is different and you want to develop different things rather than just...*

B: *Because at the end of the day even if you find out that the project doesn't actually work it doesn't matter too much because you are not actually going to be selling it. It's just a prototype. So you'd want to do something different, yes.*

Researcher: *Is it a problem that there is nothing on the market that resembles it?*

J: *No I'd say that's positive ... (all agree).*

None of the students mentioned the importance of good grades when they talked about their choice of idea. Their motivation for choosing the idea seemed to be that it was innovative and different, that *'you'd want to develop different things'*.

A property of intrinsic motivation emerges in this dialogue. *'Because at the end of the day even if you find out that the project doesn't actually work it doesn't matter too much because you are not actually going to be selling it. It's just a prototype.'* (Student)

It seems like the student was ready to take on a risk - the risk that the idea could fail in terms of a successful project. This is a unique example. While in all other parts of the interview it seemed like risk taking was a big problem and an issue with students, when the promise of innovation became present the thought that the ideas could turn out to be different, exciting and unique, students were ready to take on a risk.

A new hypothesis emerges here - that intrinsic motivation and the promise of innovation make it easier for learners to take risks and to justify these risks to themselves. Risk taking was already identified within the literature review as a necessary condition for creativity to develop in the learner (Kimbell, 2000(a)).

The need emerges for a multimedia learning environment to provide both content which would intrinsically motivate the learner and content, which would provide an opportunity for the learner to be original and innovative in their thinking.

5.7. Summary of chapter

This chapter has identified key aspects regarding the reality of A level D&T students' perceptions and experiences of creative practice within a classroom, curriculum led environment. These aspects are indicative of students' knowledge, attitudes and interests, thus providing a phenomenological basis for eliciting specific learning needs regarding creativity. As a result, on the basis of these learning needs, discussion and analysis have suggested approaches to the design of a learning environment, which can adequately support creativity in the learner. Principles for the design of such a learning environment have been extracted, such as the style of interaction, the use and desired effect of digital media. Principles for pedagogical design have further been suggested such as the theoretical approach to be adopted; the kinds of interactions necessary, as well as ways of structuring these interactions; the type of content, which is most likely to have a positive effect on creativity; the forms of stimulus which would support learning in the A level D&T learner.

The following chapter describes how the principles and design requirements derived from the Learning Needs interviews were used ad the basis for designing an interactive media learning environment. The learning environment ecoWarrior, implementing these principles, is further evaluated as a way of establishing to what extent the initial hypotheses and theories benchmarked in this chapter have been effective in enhancing learner creativity.

Chapter 6. ecoWarrior – A Prototype for an Interactive Media Learning Environment Which Aims to Address Learning and Creativity in D&T Education

6.1. Introduction

Chapter 5 provided empirical evidence of learners' experiences of creativity in the D&T classroom. Through the analysis of this evidence, specific learning needs were established, which provided a basis for the derivation of principles for the design of a multimedia learning environment, aimed at supporting learning and creativity in the subject of D&T. This chapter describes how these principles were applied to the design and implementation of an interactive multimedia learning environment, entitled ecoWarrior.

On the basis of the recommendations synthesised in Chapter 5 (see sections 5.2.7; 5.3.6; 5.4.5; 5.5.1), specific goals of instruction are derived in Chapter 6. By evaluating whether the goals of instruction were met, in Chapters 8, 9 and 10 evaluative research was able to provide answers to the specific research questions identified in Chapter 6. The ecoWarrior learning environment therefore acted as an evaluative tool, which allowed research to uncover the role of interactive media in enhancing learning and creativity in the D&T learner.

6.2. ecoWarrior - digital game-based learning for sustainable design

This section introduces the ecoWarrior learning environment. It includes a statement regarding ecoWarrior's pedagogical purpose. A map of the learning environment is provided, in order to make explicit the structure of the learning interactions. Each of the three modules included in ecoWarrior are described. The description includes an explanation of the pedagogical purpose of the module - what students are going to achieve by engaging with the module. In addition, each module description is supported by a 'rationale' section explaining the functionality of the software in a step by step manner.

ecoWarrior – Digital game-based learning for sustainable design

6.2.1. What is ecoWarrior?

EcoWarrior is an interactive game-based learning environment, which introduces learners to issues in eco design and sustainability. Originally aimed at A level learners, the resource is flexible enough to accommodate learning at GCSE level.

Students will be able to use the learning environment in the following ways:

- Get ideas for project work dealing with the subject of sustainable design;
- Learn about key issues in sustainability and work on case studies with existing products, exploring these issues;
- Work collaboratively in generating, developing and refining design ideas;
- Engage in practical hands on sketching tasks which will help them record and develop their thinking.

6.2.2. How is ecoWarrior different from other learning resources?

ecoWarrior is an interactive learning environment, which will help teachers structure lessons around the issues of sustainable design. It has two primary advantages, which make it unique:

- ecoWarrior is collaborative it will promote discussion amongst students on the issues of sustainability as well as help them generate new ideas for design projects;
- ecoWarrior is interactive - by using dynamic multiple representations of data it stimulates students' imaginations; inspires them to think about sustainability. Research shows that interactivity also aids comprehension and retention in learners therefore it can work for learners of different abilities and be flexible in supporting their learning needs equally. Through interactivity ecoWarrior will make difficult concepts in eco design

accessible to learners. In a very short period of time issues in eco design will become part of students' vocabulary and will soon start to be the basis for their project work.

6.2.3. Navigation

Following is a map of the software, making explicit the structure of the learning environment (fig. 19).

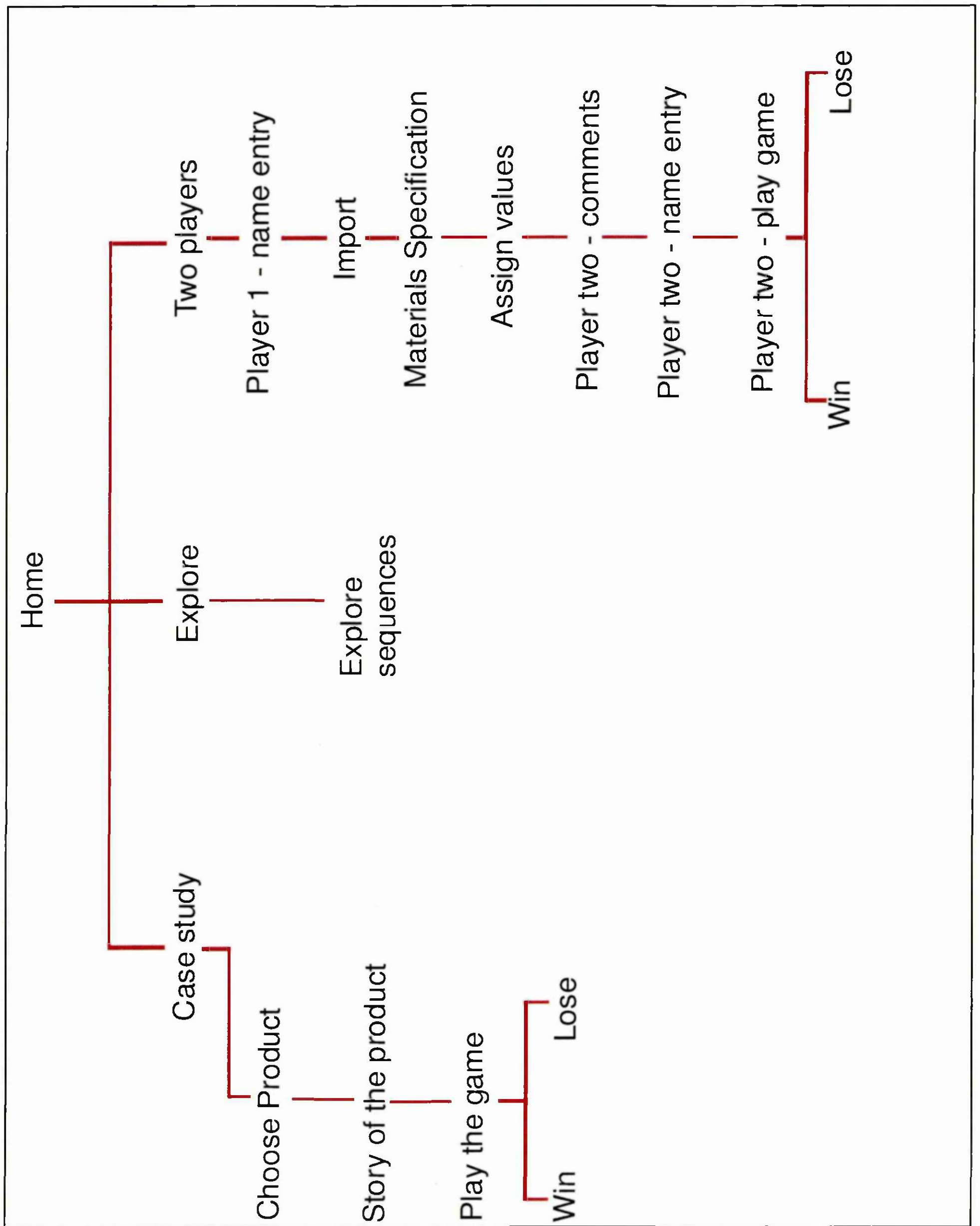
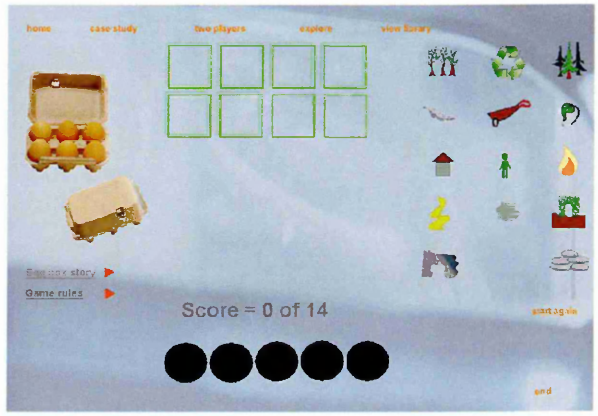


Figure 19. Navigation map of the ecoWarrior interactive learning environment

6.2.4. Case study module

For all modules in ecoWarrior it is most beneficial if students work in pairs.



The case study module aims to introduce learners to basic concepts in eco design and sustainability. It does this by placing the concepts in the context of an existing manufactured product. The learner's task is to think about how the concepts in eco design relate to the product being analysed. In making these decisions learners are simultaneously learning the concepts' meanings and learning to apply them within a realistic context - that of the existing product. The interaction is resolved as a computer game, which learners can win or lose, depending on how well they understand the concepts. The game implements some of the basic conditions of learning of declarative knowledge such as immediate feedback on users' actions, positive reinforcement, negative instances.

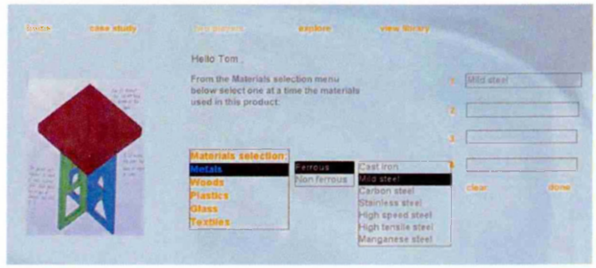
Case study module – rationale

1. Click on the 'Case study' tab in the navigation bar (from the Home screen, click and slide down to 'Case Study'). This takes you to the 'Choose a product' screen.
2. In the 'Choose a product' screen select one of the products by clicking on its image. This will take you to the 'Story of the product' screen.
3. In the 'Story of the product' screen, read the story of the product this will provide valuable information necessary for winning the game. Click 'start game' when finished. This will take you to the 'Play the game' screen.
4. In the 'Play the game' screen refer to the 'Game rules'. Play the game by dragging and dropping the concepts until you have won or lost.

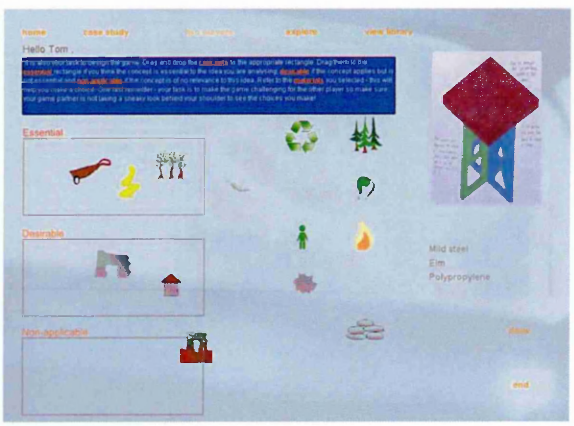
6.2.5. Two players game module

The 'Two players game' module builds on the knowledge which learners have acquired in the 'Case study' module. Once learners have acquired knowledge of the basic concepts in eco design, they have the opportunity to apply this knowledge to the context of their own work. Students work in pairs, importing an image of their own work into the system and analysing it, by using a similar structure to this in the 'Case study' module. The most significant difference with the 'Case study' module is that learners are not given any ready-made answers instead they have to make decisions on how the concepts in eco design apply to their own ideas. In this way learning moves away from the instructional approach and allows learners to construct knowledge in dialogue with each other. While engaging with the tasks, learners discuss and justify their choices, in this way creating new meaning and seeing their work from a different perspective.

Two players game module rationale



1. Students work in pairs. Click on the 2 Players tab.
2. Player 1 enters their name in the field provided. Click done.
3. Click on the import button to import your own image, or browse to the AddNew folder to select an image. Click done when finished. This takes you to the 'Materials selection' screen.
4. Work together. From the Materials Selection menu select the materials, which the product in the sketch uses. If the material is not listed, you can also type it in. Click done when finished. This takes you to the 'Assign values' screen.



5. Player 1 now needs to assign values to each of the concepts in eco design, depending on how they relate to the idea in the sketch. Choose from essential, desirable or non-applicable. If you have forgotten what the concepts mean, click on each concept to read or hear its meaning. Any concepts you leave out will count as non-applicable. Attention! Your game partner, player 2, should not see the choices you are making! Click done when finished. This takes you to the 'Player two: play game' screen.
6. Player 2, enter your name. Click 'done'. This takes you to the 'Player 2 Comments' screen.
7. Player 2, in this screen write down any comments you may have about how sustainable the design idea is.
8 You now have to play the game your game partner has designed. Read the game rules. Remember if you disagree with any of the choices they have made you have to discuss this. If the two of you agree on a change, click on ‘back to assign values’.
9. Continue playing until one of you wins or loses.

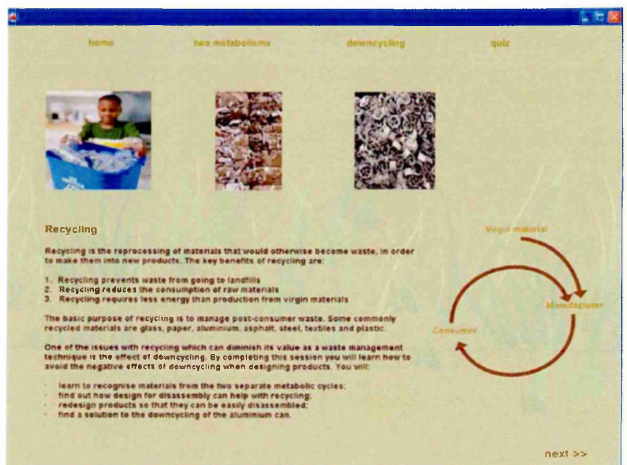
6.2.6. Explore module

The Explore module is a further exploration of the concepts in eco design, which you have been working with so far. In simple terms it places an abstract concept, for example compostability, in the context of broader issues. The Explore module answers questions such as 'Why is it important to compost?', 'How does it affect our lives and the lives of other people?', ' How are the services related to composting organised?' Having such real world knowledge of the issues of eco design students will then find it easier to respond creatively to these issues.

The Explore module involves practical sketching tasks, which students can use as a way of generating new ideas or developing an idea they have brought into the learning environment.

Explore module rationale

1. Click on the explore tab. An intermediary window with a pink background appears.
2. Click on the concept you want to explore further.
3. Carefully read the information provided, complete the interactive tasks and the quiz. As you go along you will be asked to work on various sketching tasks. Write down or draw any ideas you come up with in response to these sketching tasks.



6.3. Rationale for the derivation of an interactive media learning environment which aims to address learning and creativity in the D&T learner

6.3.1. Synthesis of research questions

This section categorises the specific research questions relating to the design of the ecoWarrior interactive learning environment, according to the specific aspect of learning design they relate to.

This research aims to establish strategies for enhancing creativity in the learner. As the literature review chapters 1 and 2 as well as chapter 5 identified, in order to influence learner creativity the instructional system needs to target the affective layer of learning. The unifying research question bringing all of the sub questions together is formulated as:

How can interactive media provide the necessary conditions for the affective factors of learning characteristic of creativity to develop in the learner?

Below is a summary of the research questions, which evaluation was concerned with:

Structuring learning content and learning interactions - approach to learning theory

- Is the computer capable of triggering dialogue in learners? Is the dialogue valuable (deep) or surface? What are the specific conditions – type of media, style of interaction, etc, which make such dialogue possible?
- Does the system support ideas being generated in dialogue?
- Does reflective thought develop in dialogue?
- What should the relationship between learner and computer be in terms of forms of dialogue?
- Is discovering what is to be learned valuable?
- Does the system manage to support experiential learning? Do students resort to their past experiences as a way of making sense of the learning material and building new knowledge?

- Can a discovery system provide the necessary conditions for learning? Will it be able to sustain the interest of the learner and be inspirational enough for the learner to carry the experience / knowledge in their own work?
- Do students show signs that they are carrying knowledge acquired within the artificial learning situation of the game into their own project work?

User control and autonomy

- How much guidance is necessary?
- How much instruction is it necessary to provide?
- How should the issue of learner versus system control be resolved in the learning interactions in order to support learner autonomy?
- How should the amount and type of feedback be resolved in order to allow for learners to meaningfully engage with the learning content?

Structuring the learning interactions - interface design which supports learning and creativity:

- Does direct manipulation support the learner to interact/converse/reflect?
- Are the elements of games design used in the learning environment motivational and stimulating?
- Are learners more involved with the interface and finding out how the game works or is there a sense of direct involvement with the task at hand? Does the interface become invisible (Shneiderman, 1998; Lansdale, 1995)?

Affective factors which influence learner creativity

- Are learners intrinsically motivated / excited as a result of playing the game?
- Do students find the material relevant to their own work? Do they make the relationship between their own work and the context they are exposed to in the system?
- Are the learning interactions designed in a way which will encourage students to exercise free will? What is the role / value / significance of elements such as reward, positive feedback, engaging content within this?

- Is the learner more autonomous as a result of using the system?

The evaluation of the learning environment aimed to provide answers to these questions. Evaluation further sought to identify the specific conditions which made learning and creativity possible. These conditions were then utilised to form the core of a set of guidelines for the design of interactive learning environments, which aimed to support creativity and original thought in the D&T learner.

Since it was these guidelines, which were the desired outcome of evaluation, and not the accomplishment of the learning environment as a finished entity, the learning environment needs to be seen as a tool for evaluation, not as a finished product. The standpoint of this research, originating from an action research methodology, was that designing and evaluating a learning environment is the optimum way to learn about the issues, which exist and identify ways of addressing these issues. Designing a learning environment provides the desired intervention in a learning setting, which allows us to learn about how to enhance the learning setting (Cohen, 2000(c)).

6.3.2. The need for instruction - identifying the appropriate content

In every learning environment a specific content needs to be identified, arising from a particular need for instruction (Gagne, Briggs, Wager, 1988). While the aim of research was to uncover conditions which supported affective factors in learning, a focus on creativity does not constitute content in itself. A specific need for instruction which is sympathetic to the D&T A level curriculum needed to be identified and made the focus of instruction. In the case of this research, the need for instruction is derived from the indications, which interview data had given for context rich content, as well as the nature of the projects currently at the forefront of design education (see section 5.3.1).

As the Learning Needs interviews pointed out, students struggled to find a context to work within when faced with a self-directed project. They need to become aware of the wider issues and implications of designing, such as the increasing need for products to be sustainable. Sustainability is at the forefront of design education, not only at secondary but at undergraduate and postgraduate degree level. It equally strongly affects the way design practice is evolving in industry. In other words – sustainability is a hot topic of debate, and an exciting area for designers, which is gaining an ever-increasing focus in education.

Therefore the need for instruction lies in being able to combine awareness of design issues in context with knowledge of sustainable design. Such awareness of design issues in context can address the issue of originality of students' work. It is hoped that through seeing their work from a different perspective - that of sustainable design - learners will be able to come up with innovative and original ideas.

Further, the more knowledge students have of the wider contexts of designing, the more increased their chances are of being in a position to identify their own contexts to work within rather than relying on the teacher to suggest these. As the Learning Needs interviews identified, the learner is dependent on the teacher in decision-making and this stifles creative potential. The learner needs to start thinking for themselves - this is a step towards realising themselves as creative individuals.

It was also identified that students needed stimulus and motivation - a form of inspiration - in order to engage creatively with the task at hand. Another goal of learning content therefore was that it should function as a source of inspiration – inspirational material.

6.3.3. Goals:

As discussed previously, the goals of instruction are different from the goals of the research project, outlined in section 6.3.1. However, it was necessary to keep a firm focus on the goals of instruction, since it was in the process of achieving the goals of instruction that learners would provide answers to the questions of the research project. These answers would be found in the manner in which they interacted with the learning environment, the degree of success they had in their learning interactions and the amount of learning they elicited from these interactions.

Below is a synthesis of the goals of instruction, which need to be fulfilled in order to address learning and creativity in the learner:

- Provide students with a wider range of contexts to work within;
- Help students see their work from a different perspective;
- Encourage reflexivity, dialogue and generative thought in students.

Further than this, the system has to offer the opportunity for learners to realise their own individual goals. If the learning environment fully defines the goals for the learner, it is likely that learners will achieve the prescribed goals but this will not necessarily aid them in constructing their own individual goals as independent, creative learners. Therefore perhaps the most significant goal of instruction stands as:

- Making the learner independent and free-thinking, helping them realise themselves as creative individuals

This can only happen if the learner sees the relevance of the learning material to the context of their own work, and is further able to carry the learning experience into their own design work. In this way learners will have a richer context to choose from and will not depend on the teacher to suggest lines of enquiry or contexts to work within. Each student project is individual and different. The goal of the learning experience is to promote this difference and individuality - to be able to carry a context, which is common to everyone into a project, which is individual for each learner. Therefore the system needs to be flexible enough to aid the learner in establishing their own goals. The need to support the learner in identifying their individual goals is the point, which makes Gagne's systems approach (Gagne et. al., 1988: 121) incomplete, and necessitates discovery as a learning strategy.

We have to acknowledge therefore, that in this case the goals of instruction cannot be fully defined by the designer of the learning content and that, where creativity is concerned, some of these goals are in fact specific and individual to each learner. The learning content designer's task within this is to provide an environment, in which the learner is supported in discovering and identifying these individual goals. Only in this way can we ensure that the learners will be able to carry the experiences out of the abstract context of the learning environment and into their own design project work.

Gagne's Systems approach (Gagne et. al., 1988: 121) will be used as a way of deriving the instructional system. It will also provide a structure for evaluation of the learning environment (see fig. 20).

module

↓

target objectives

↓

capabilities

↓

performance objectives

↓

conditions of learning

↓

media

↓

assessment criteria

Figure 20 Gagne's systems approach

An important point needs to be made here – as with the goals of instructions, fulfilling the target objectives by the learner is not an end in itself within this research. Rather, observing *the way in which learners achieved the target objectives* would be used to provide answers to the research questions identified and ultimately inform the formation of a strategy for the design of interactive learning environments, which support learning and creativity. Therefore, Gagne's Systems Approach was used in a more focused way, placing specific emphasis on how the target objectives were met and what the conditions of learning were within this (fig. 21).

description of module

↓

target objectives

↓

research questions

↓

conditions of learning / design features

↓

methods of data gathering and analysis

Figure 21 Gagne's systems approach adapted

The following section will:

- Make explicit the design of the instructional system, describing design features and functionality;
- State the target objectives which learners are expected to meet. These target objectives are specific for each of the main modules within the learning environment - *Case study, Two players and Explore*;
- Identify the research questions which the achievement of each target objective on the side of the learner will allow research to explore
- Identify specific design features and strategies within the learning environment, which support the target objectives identified
- Give an indication of the methods of data gathering, which will allow research to evaluate whether the target objectives have been met and how will the conditions of learning for each target objective have contributed to this.

6.3.4. Case study module

Module Description

(see Appendix 6 for a full description of ecoWarrior's functionality)

The *Case Study* module aims to introduce learners to issues in eco design and sustainability. Learners choose a product to interact with and are then introduced to a short narrative description of the product. The narrative description provides focused information, which, if read carefully by the learner will provide them with the knowledge necessary to be able to interpret the product in terms of its sustainability.

The product being analysed is then placed within a game-like interactive structure. The learner is introduced to a series of concepts in eco design. Having familiarised themselves with the concepts' meanings, learners need to make a decision on which concepts apply to the product analysed. The interaction is resolved as a drag-and-drop game. Immediate feedback is given on learners' actions. Positive reinforcement is given on each correct choice and on winning the game.

Target objective

The target objective of this module is to introduce the learner to basic concepts in eco-design and sustainability.

It is necessary to acknowledge that for the purposes of this study, the selection of content, which deals with sustainability, was restricted to a single strategy approach, focusing on materials selection and use. Research has taken into consideration the fact that in approaches to sustainable design, in industry as well as from a pedagogical point of view, such a focus is known as a single strategy approach and is considered to have limited potential as compared to a full cycle sustainability analysis. Nevertheless, this was considered appropriate since the system's use aimed to explore learners' perceptions of the subject matter in-depth, while being confined to a limited period of time. Thus it was deemed more appropriate to explore a single use approach in more depth rather than dividing learners' attention by trying to introduce a large amount of complex content over a short period of time.

The purpose of this module is to support the formation of concrete concepts, where the learner is able to class a concept according to its properties. The objective is further to aid the acquisition of verbal information (see Glossary) –

i.e. factual, declarative knowledge. This is necessary, since in order to proceed to supporting the construction of more complex intellectual skills, such as are involved in original thinking and creativity, the learner firstly needs to have a firm grounding in subject knowledge.

Research questions for Case Study module

Observing students' performance on this module allowed research to evaluate the effectiveness of direct manipulation as a way of stimulating the learner to interact with and reflect on the content:

- Are learners learning the concrete knowledge embedded in the learning interactions?
- Do the elements of games design work – i.e. – does direct manipulation support the learner to interact / converse / reflect?
- Are learners more involved with the interface / finding out how the game works or is there a sense of direct involvement with the task at hand? In other words - does the interface become invisible?

Direct manipulation is a feature characteristic of the games design metaphor of interaction. Some elements of games design, which the module supports, are:

- The score;
- Immediate feedback on users' actions;
- Reward upon completing the exercise successfully / winning the game.

Each of these features has the primary function of providing the necessary stimulus for the learner to engage and interact with the learning content. As research literature identifies - stimulus and motivation to engage is one of the primary benefits of utilising game-based learning (BECTA, 2001; Prensky, 2001).

Conditions of learning provided and design principles

Gagne identifies the essential conditions necessary for learning concrete concepts and intellectual skills. The following are features which the ecoWarrior learning environment includes, and which are directly derived from the conditions of learning identified by Gagne:

- Reinforcement – *'Learning a new fact is strengthened when the occurrence of that fact is followed by a satisfying state of affairs (that is, a reward)'* (Thorndike in Gagne, 1988: 8).

Positive feedback relative to the user's action is given – a pleasant sound follows each correct answer and a number is added to the score. On winning the game the learner receives a reward - music is played and a tree dances amongst *'well done'* animated signs. This reward aims to reinforce the learner's desire to perform well - in order to win the game, the learner has to learn the concepts. Similarly the score is a technique in games design, which encourages mastery in the learner.

- Provide an opportunity for the learner to assign the concepts to a class

In the case of the ecoWarrior Case Study – the drag-and-drop game is based on the principle of assigning concepts to a class. The learner has to select which concepts apply to the product being analysed. In this case the product itself represents a class.

Methods of evaluation

Observation and concurrent protocol analysis

The optimum way of evaluating whether direct manipulation adequately supports the learner in meaning making, was to find a way of establishing whether students are learning from the interaction. The target objective identified in this case is that students must be able to identify the concepts, which apply to the product being analysed, and classify them. Their drag-and-drop actions should be based on logic as opposed to luck. One way of monitoring this was to ask them to talk while they were interacting with the learning experience. The method used was *concurrent protocol analysis* (see Glossary). If their thinking showed signs of constructing a rule based system – such as 'natural materials are generally renewable' – then this was an indication that they had learned and are applying an *intellectual skill* (see Glossary).

Using concurrent protocol analysis as a method of evaluation has its critiques, as it has been identified to *'interfere with task performance'* (Lindgaard, 1994). This is why concurrent protocol analysis was used sparingly within this research, as well as combined with other methods, which could give a more comprehensive outlook on the learner's experience.

Intrinsic motivation

Apart from observing whether learners engaged in meaning making, it was necessary to observe the nature of the learners' motivation in engaging with the learning content, while interacting with the *Case Studies*. As research literature identifies, creativity and original thinking are much more likely to develop in an intrinsically motivated learner (Hennessey & Amabile, 1988). Therefore intrinsic motivation such as pleasure expressed by learners in engaging with the learning interactions, was a desired result in terms of the necessary conditions for predisposing the learner towards creativity.

The degree of involvement, which the learner displayed when engaging with the task made it possible to make judgements about the nature of the learner's motivation.

Research question on intrinsic motivation:

- Are learners intrinsically motivated / excited as a result of playing the game?

Such affective factors were revealed through observing learners' body language and the degree of involvement they displayed as well as the depth of their emotional response in interacting with the learning environment.

Methods of data gathering and interpretation

Video observation, concurrent protocol analysis, discourse analysis

Evaluation looked for active body language, degree of involvement, verbal expressions which conveyed excitement.

The interface

The *Case Study* module provides a way of evaluating the pedagogic responsiveness of the interface. One of the important elements of the system is to make the interface 'invisible', and in this way focus the learner's attention entirely on the task at hand, making it easier to breach the gap between reflection and action, as a way of supporting reflective thinking (see section 5.4).

Research question on interface:

- Are learners more involved with the interface and finding out how the game works or is there a sense of direct involvement with the task at hand?
- Does the interface become invisible?

Conditions of learning and design principles for making the interface invisible

A necessary condition for learning in this case is repetition. Schneider and Shiffrin (Lansdale, 1995: 144) identify two types of cognitive processing – controlled and automatic. While controlled cognitive processing requires active thought and the user's full attention, automatic processing does not. From this point of view, the interface design will be successful if the cognitive processing involved in using it becomes automatic. If controlled processes became automated we could say that we had provided an opportunity for the learner to focus their entire attention on the task at hand, making the interface effortless and invisible.

Methods of data gathering and interpretation

Observation, concurrent protocol analysis, conversation analysis

Relevant questions which evaluation through these methods could ask were:

- At what point in using the system do learners' conversations shift from discussing and finding out how the interface works to a discussion fully focused on the learning content?

- Is there hesitation in their interactions with the system about what the learning outcome is, or about how to manipulate the interface?
- At what point in the interactions do learners start to become confident in using it and utilise its capacity for providing them not only with pathways through content but also with a personal cognitive space?

6.3.5. Two players game module

As was said earlier, the underlying teaching strategy of this research is the shift from context to abstraction – from understanding a topic of study within a single context, towards understanding and being able to apply the topic to new contexts. This shift is known as situating learning (Lave and Wenger, 1991(a)). If something, which students had to think about deeply, they could now make judgements about immediately and intuitively, this meant they had learned the concrete concepts. The next stage was to repeat the exercise with a number of different contexts. If they could apply the knowledge they have acquired in one product to others that meant they had come some way towards learning the abstraction. Proof that students had learned the abstraction was if they could apply it within a design idea of their own.

The exercise in the *Case Study* module only goes as far as teaching the context. The next step will be to think about how to make the shift towards abstraction? How to truly situate learning? How to aid the learner in applying the knowledge they have acquired from the artificial context of the game within the realistic context of their own work? This is where the relevance of the *Two Players Game* and the *Explore* modules comes in.

Module description

The *Two Players Game* module builds on the skills and knowledge, which the learner has acquired within the *Case Study* module. Learners interact with the module in pairs. One learner is asked to import an image of their ongoing work into the learning environment – this could be a sketch of an initial design idea the student is working on.

The learner then has to specify the materials which the product idea is using. This is the equivalent of writing a short, materials specification for the product idea and aims to get students to consider an aspect of the idea, which they will probably not have considered in detail so far. In this way the *Materials Selection Menu* is intended as a reflective feature.

Once the materials have been specified, the learner proceeds to the *Assign Values* screen (see Appendix 6). This is where the declarative knowledge and intellectual skills acquired in the *Case Study* sequences are utilised and built on. The product idea, together with its materials specification constructed by the learner, are placed in the context of the same concepts of eco design used in the *Case Study* sequences. The learner has to assign values to each concept according to how relevant and applicable the concept is to their product idea. In this way the learner is actively reflecting on the qualities of their design idea in terms of its potential for sustainability.

The learner is able to see their idea from a different perspective which, as discussed earlier, is a fulcrum for the development of creative thought (see section 5.2.2). Finally, the learner is able to make informed choices because they are working with their own design idea as well as because they are familiar with and comfortable in manipulating the eco design concepts after having engaged in the *Case Study* sequences.

The second learner has to play the game, which the first learner has designed. In playing the game, the second learner is providing a response both to the product idea of the first learner and to the choices, which the first learner has made in terms of how eco-friendly the idea is. In this way, an opportunity for dialogue is created, where the second learner is in fact interpreting the design from a different point of view. Thus the opportunity for the development of thinking is embedded into the system.

Target objective – learning which is personally relevant

The key target objective associated with the *Two Players* module is to engage the learner in thinking. Mercer identifies that learning takes place when the cognitive conflict becomes personally relevant (Mercer, 2000(b)). Therefore the target objective of the learner is to be able to relate the content and interactions within the learning environment to their own work, or alternatively – to carry the ideas and thoughts generated within this learning environment into actual design work of their own.

It is necessary to explore whether and to what extent the development of thinking becoming personally relevant has repercussions on the affective layer of learning and therefore – creativity. Where this aspect of learning existed, it was of specific interest to this research, since as the contextual review discussed, affective factors of learning have a significant influence on learner creativity. The questions relating to this aspect of research were:

- Does learning become personally relevant?
- What are the specific conditions – type of media, style of interaction, etc, which contribute to the development of learning as personally relevant?
- Does learning becoming personally relevant have an effect on the affective layer of learning? Is there evidence that this affects learner creativity?

Conditions of learning and design features

The *Two Players* module is structured in a way which aims to encourage learning and make this learning personally relevant.

Several features within the ecoWarrior learning environment provide a way of personalising learning content. By asking learners to import an image of their own work and use this as the basis for their analysis, the learning environment became personalised to each learner's interests. From this point onwards all interactions were focused on the learner's own work and any learning which develops as a result has the potential of becoming personally relevant.

A supplementary feature within ecoWarrior, which was built in to alert the learner to the fact that their exploration is personally relevant, was the Name Entry feature – once the learner has entered their name, the system addresses them by this name. Therefore all learning interactions became personalised.

Other features, which encouraged the development of thinking in the learner were the *Materials Specification menu* and the *Assign Values* feature. Both of these were targeted at encouraging an attitude of deep reflection and active thinking in the learner.

The *Materials Specification* menu asks learners to consider the materials they use in a product. At the same time however learners were interacting with this content in a way, which directly related to their own generated ideas. As the analysis of the ecoWarrior evaluation made explicit, such reflective thought, which uses personal ideas as content naturally encourages deep reflection in the learner (see section 9.3).

The *Assign Values* feature builds on the *Materials Specification* menus. It makes the relationship between the new content embedded within the learning environment – that of eco design – and the learner's own project work. This is the stage where the learning environment moves away from the acquisition of declarative knowledge 'knowing that' (Gagne, Briggs, Wager, 1988: 46) and focuses instead on mastering cognitive strategies (see Glossary). Crucially, this is the stage where learning moves away from an instructional design approach. From this point onwards the decision on whether the choices, which the learner made were right or wrong, was entirely the learners' own decision. Such active involvement on the side of the learners made the Two Players module a constructivist learning experience.

Learning and affective factors

The fact that learners created, negotiated, discussed and co-produced meaning within the learning environment had a significant impact on their autonomy. As was identified in research literature (Rutland and Barlex, 2002; NACCCE, 1999) and further reinforced through the Learning Needs interviews (see section 5.3) one of the key conditions for creativity is learner autonomy. When interacting with ecoWarrior, learners acted within a constructivist learning set up – the meaning which they created was not regulated by an external authority figure, it was entirely produced, evaluated and negotiated by the learning pair. In this egalitarian structure to the learning interactions there was more possibility for self-expression in learners and an increased opportunity for them to develop as autonomous learners. All of these – self-expression, autonomy, increased self-esteem - are affective factors of learning and all of them contribute to the development of creativity in the learner. The evaluation of ecoWarrior therefore focused on evaluating the extent to which the learning environment afforded for these factors to develop in the learner.

To summarise, the conditions of learning discussed within the Two Players module:

- A social constructivist learning set up;
- A learner who is active towards meaning making within this environment;
- A minimal intervention from an authority figure;
- The opportunity to acquire cognitive strategies.

Competition and learning

The metaphor of the two players game has an important role in learning. When this set up of interactions is combined with placing the two learners in opposition to each other, one of them has to win and the other will inevitably lose, a situation of cognitive conflict is achieved. The purpose of evaluation in this instance was to establish:

- In what ways does the element of competition affect learning?

Levels of learner control and making learning personally relevant

The possibility of learners saving their work in the system and being able to manipulate their own ideas on screen as part of the content originally built into the system, contributes to learners creating personal cognitive space. Bekier identifies the ability to create personal cognitive space as one of the highest levels of learner control (Bekier, 2005). Therefore the research question which the evaluation of ecoWarrior aimed to answer as regards learner control was:

- Does the level of learner control afforded by the learning environment have an impact on making learning personally relevant?

Methods of data gathering and interpretation

Concurrent protocol analysis, observation

Since a significant part of the interactions within the *Two Players Game* module do not lend themselves to verbal expression (for example the *Materials Specification* menu and the *Assign Values* feature), but rather – to internal reflective thought – concurrent protocol analysis in combination with observation was used to evaluate the learner's thinking.

Observation was particularly useful in analysing the choices and actions of each learner in the game.

As there was an element of competition in the interactions, the impact of this on learner-to-learner interactions was analysed by using a method which allowed the researcher to understand the reasons why learners were acting in a certain way. Conversation analysis was an appropriate method to use in this respect as Chapter 7 will discuss in more detail.

6.3.6. Explore module

The *Explore* module takes a further step towards situating learning – from being able to manipulate knowledge within a specific context to being able to apply knowledge in a real world context. The learning environment's task within this is to allow for students to understand the concepts of eco design on a deeper level - not only in terms of their definition, but also in terms of why the concepts are necessary. For example - we know what biodegradable means by definition but why is it necessary for a material to be biodegradable? Where does it fit into our lives?

There is a marked progression from the *Case Study* module to the *Explore* module, in that we are now moving from providing the necessary knowledge to the learner and merely allowing them to develop a taste for the meaning (stimulating curiosity), to providing an environment which allows them to situate what they have learned within a real life context, as well as take the experience away with them. Within this the outcomes of instruction move from providing ways of learning *verbal information* to facilitating learners in acquiring *cognitive strategies* – learning how to think (see Glossary).

An essential goal of situating learning in a real world context is that only when learners start to understand why eco design and sustainability are necessary as design strategies, that they will begin to change their attitude towards the subject matter and will start seeing their own work from a different perspective. In this sense situating learning is itself a way of facilitating a change in the learners' attitude.

Module description

The *'Explore'* module combines narrative and interactive sequences as well as activities in order to allow the learner to explore the distinct concepts of eco design in the learning environment in more depth, to the extent that would allow them to situate their learning of these concepts within a real world context.

The *'Explore'* narrative sequences are associated with each distinct concept ('renewable', 'compostable', 'durable' etc). Their role is to provide the learners with more in-depth information of the eco design concepts implicated in the system. Their use is envisaged especially where two students are having a dispute of how a certain concept applies to the product they are analysing. They use the narrative form as a way of placing the concept in the wider context of related issues. The learner is exposed to the narrative element, experiencing the concept in a realistic context. For example in the 'compostable' sequence the narrative sequences show the learner how people manage composting on a small scale – backyard composting – and on a larger, more organised scale – municipal composting.

The interactive sequences function alongside and as part of the narrative content. In a sense the narrative sequences aim to engage the learner in reflecting on the issue, while the interactive ones engage them in task oriented problem solving learning. The aim of both narrative and interactive sequences is to provide sufficient content and stimulus to the learner in order to bring them to a stage where they are informed and intrinsically motivated enough to be willing to engage in creative thought.

The *Sketching tasks* are the third, essential element of the *Explore* sequences. These are focused tasks, which ask the learner to engage in original, generative thinking. The sketching task activities are closely interrelated with the context provided by the narrative and interactive elements of the *Explore* sequence. The purpose of these activities is that learners should be able to act upon the content they are seeing on screen.

Target objectives

Target Objective 1 - Communication

As the social constructivist perspective maintains, meaning is developed, co-produced and thus situated within a social world (Vygotsky, 1978). In this way, the research sees dialogic verbal communication as having an essential role in situating learning, which in turn has an influence on the affective layer of learning.

Further, a learner needs to be able to communicate their idea to other learners – defend, explain, argue a point, compare, contrast, criticise. Being able to do this means that the learner has acquired a *cognitive strategy* (see Glossary). This is a higher order cognitive skill to that of declarative knowledge, which will allow them to carry the experience of learning in the real world context of their own work.

In order to be able to observe and evaluate the development of these communication skills developing in the learner, research looked for evidence in the dialogue which developed, of learners being able to construct an argument, question the way the other player perceives the learning content and defend their own ideas. In relation to such communication skills developing in the learner, research aimed to explore the following specific questions:

- Does the learning environment afford for learning which is situated within a social context?
- Is the computer capable of triggering dialogue in learners? Is the dialogue valuable (deep) or surface?
- Does the dialogue, which develops between learners, support the development of generative and reflective thought?

- What are the specific conditions – type of media, style of interaction, etc, which make such dialogue possible?

The evaluation of ecoWarrior looked specifically for instances of how well the system provided the necessary information and conditions for dialogue to develop.

Further, research needed to consider the impact, which such dialogue had on generative thought. As was discussed in section 2.1.4, Mercer provides a useful categorisation of types of talk, according to the function the individual performs when using them. Using this classification of types of talk and making careful observations of the situations and conditions in which such talk develops, learners' conversations helped understand how the design of the learning environment and the design of the learning interactions influenced the type of dialogue which developed in learners. This gave indications of how to support creativity and original thought in the learner through careful design of the learning environment and learning interactions. The research question posed in this instance was:

- What are the specific conditions, which afford for original thinking to develop in dialogue?

Target objective 2 - Discover individual meaning

Much like communication, this target objective was also concerned with working on the affective layer as well as situating learning:

- Understand not only what the concept is, but why is the concept necessary - appreciate the significance of issues of eco design in a real world context (situated learning);
- Be able to carry the experience into the context of students' own work – both present and future.

The research question, related to this target objective, was:

- Do students show signs that they are carrying knowledge acquired within the artificial learning situation of the game into their own project work?

The best way to observe this phenomenon of situating learning was to look for instances in the students' dialogue – were they incorporating the new knowledge embedded in the learning environment in their arguments? Were they referring to the new knowledge acquired in the context of their own work?

The ability of the student to 'take knowledge away' and apply it to their own work was also be an indication of a more autonomous learner. Whether the learner had become more autonomous will further manifest itself in the language they used and the confidence with which they approached a topic.

Target Objective 3 - Change in attitude (common to all modules in ecoWarrior)

This research's concern with the affective factors of learning brings us back to the need to address creativity and the development of original thought in the learner. If the creative aspect of learning was to be addressed – the learning environment had to ensure students' perceptions had been influenced and the ways in which they saw their own work broadened. These could all be classified as *changes in attitude* - one of the basic learning capabilities (Gagne, 1985(a): 13). As was identified in the literature review – the factors necessary for enhancing learner creativity - opportunity for self-expression, intrinsic motivation, increased self-esteem – all related to affective factors of learning. Thus by targeting the affective layer, the learning environment was targeting the issue of enhancing leaner creativity. Unless the system managed to effect a change in attitude it was doubtful whether the learner would be able to take this inspiration out of the artificial situation of the academic setting and apply it into the real world – their own project work.

The research question this target objective informed was:

- How to design the content and learning interactions in a way, which will affect a change in the learner's attitude – both towards their own work and towards the subject of eco design? What is the role / value /

significance of elements such as reward, positive feedback, engaging content within this?

One way of observing a change in attitude was to determine how readily students learned. Learning readily implies being intrinsically motivated and intrinsic motivation is a necessary condition for creativity (Hennessey and Amabile, 1988).

Bloom and Krathwohl identify that attitudes have cognitive and affective components. (Krathwohl and Bloom in Romiszowski, 1988). Changes in the affective layer are therefore brought about equally by knowledge of the learning content and the emotional response, which this content is able to elicit in the learner. This is why the *Case Study* module, which introduced declarative subject knowledge, was just as important to attitude change as the *Explore* sequences which primarily dealt with eliciting emotional response and applying this in idea generation.

Based on Bloom and Krathwohl's ideas, the following were some instances of student performance, which indicated a change in attitude:

- Willingness to explore ideas purposefully - Going to the *'Explore'* sequences out of genuine interest, and looking for specific meaning, having an individual goal, an idea of what needs to be understood
- Referring to their own work in the context of the concepts in eco design – e.g. – *"I could use an Aluminium frame then the chair will be renewable and lightweight"*
- Referring to the concepts in a context, which is external (not suggested by the learning experience) – e.g. – *"My brother's garden light uses renewable energy"*. This takes the concept "renewable" out of the artificial context of the game and places it (*situates it*) in the context of a personal, real world experience.

Conditions of learning and design principles

Element of collaboration

ecoWarrior comes with the general recommendation that learners should interact with the learning environment in pairs. The value of the learning pair as a collaborative and creative entity has already been explored in section 2.1.3. While no specific provisions were made for collaboration within the design of the learning environment, ecoWarrior delivered content, the value of which was greatly enhanced by discussion between learners. The design features of ecoWarrior which supported discussion were:

- narrative, story telling features;
- interactive features such as simulations or games;
- activity led exercises – the *Sketching Tasks*.

This section discusses in more detail how each of these elements contributed to learning and creativity.

The narrative element

As was discussed in section 2.1.2 narrative is seen as the most powerful tool for eliciting emotional response in the learner. Since the content of ecoWarrior aimed to effect a change in the learners' attitude, narrative was employed in the learning environment with this specific purpose.

Strategies such as call and response (Mercer, 2002(a)) were employed within the story elements of the *Explore* module – learners were addressed directly in order to elicit an immediate reaction. For example – the *Sustainable energy sources* introduction asked learners to think of their role as designers of the future. It addressed learners in first person in order to emphasise that this was their personal responsibility, rather than just a general issue (fig. 22).

Further the narrative elements were always related to an interactive sequence, and were always accompanied by a *Sketching task*. In this way the learner was compelled to act on the information given. Thus narrative aimed to make the best use of the emotional response, which was engendered in the learner by providing an opportunity for them to act on this response immediately with generative thought.

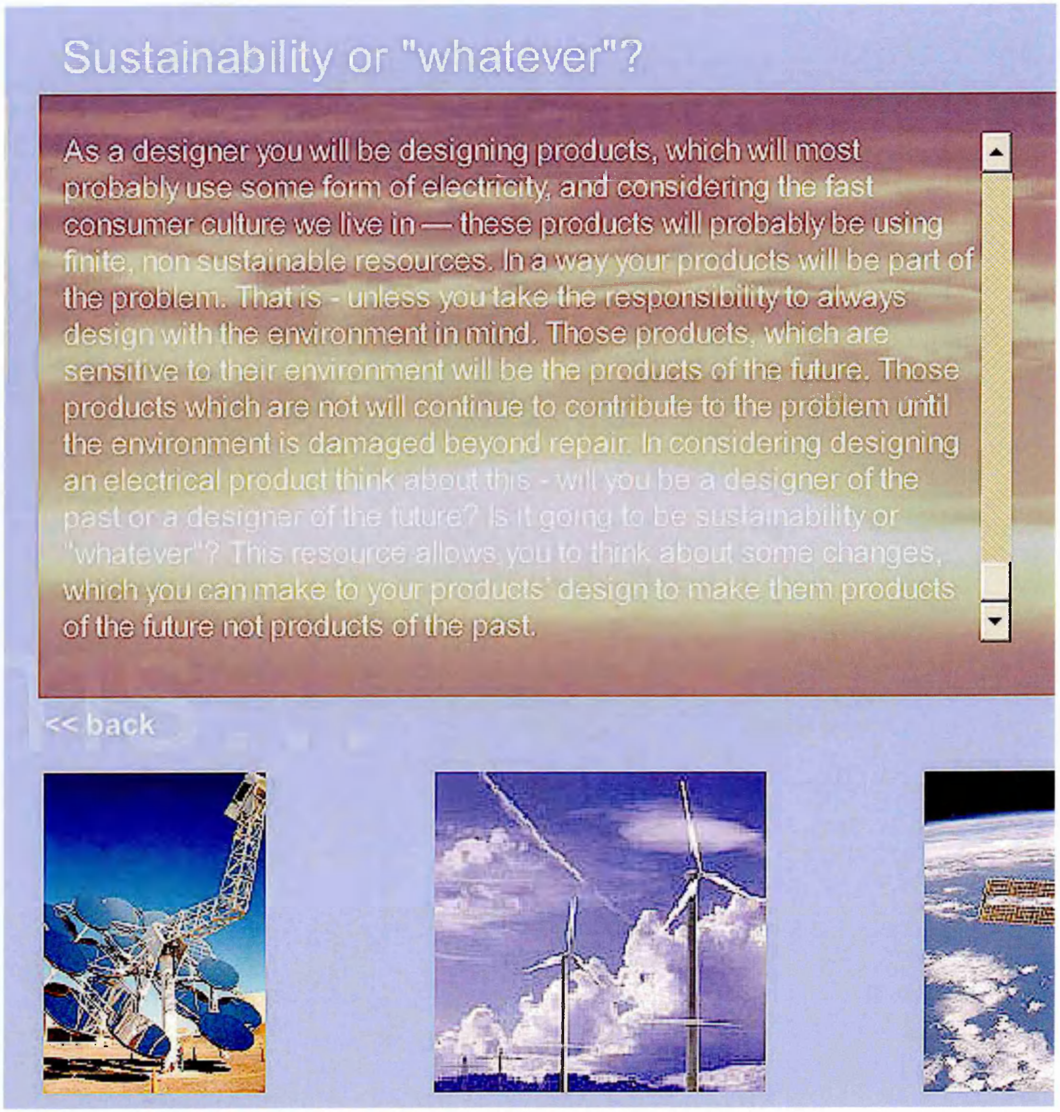


Figure 22 The use of narrative – addressing learners in first person in order to emphasise personal responsibility

Simulation and interactivity

The interactive features of ecoWarrior work in relation to the narrative content. One advantage of the interactive element is that it provides the type of constructivist learning, which section 2.3.3 identified as appropriate for the D&T learner.

As was discussed earlier all interactive elements stem from a story element. The sketching tasks, which follow the activity, require that learners should respond to a design brief to design or improve a solar cooker (fig. 23). In this way learners were engaged in generative thinking and the construction of artefacts. These artefacts were shared with the learning community, since learners worked in pairs, as well as discussed their solutions with their teacher.

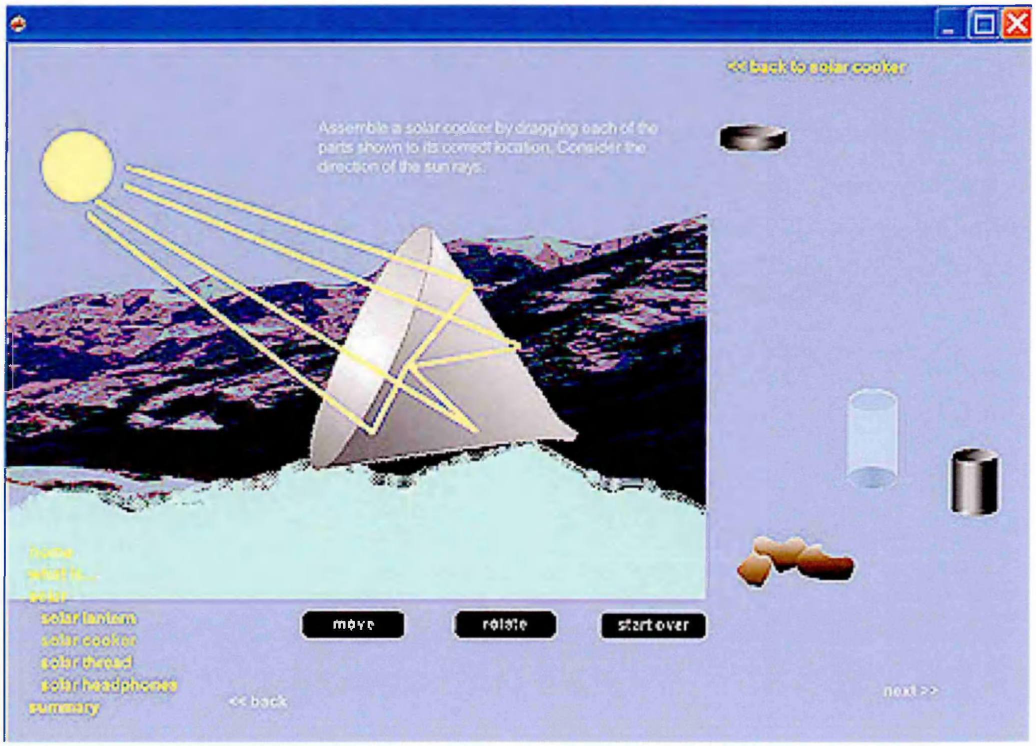


Figure 23 A simulation activity – learners have to assemble a solar cooker

Sketching tasks

The *Sketching Tasks* were an essential element in making an instructional sequence, which aimed to enhance learning and creativity in the learner complete. The *Sketching Tasks* provided an opportunity for generative thought to develop in the learner. Once again, coming from the constructivist learning perspective, the sketching tasks allowed the learner to engage in offering their own solution to the issues discussed in the learning environment.

It is important to emphasise that the sketching tasks were an integral part of the narrative and interactive content. They provided a continuation of the thought, which developed in learners by engaging with this content and bringing it into an original generative thinking response.

Methods of data gathering and interpretation

Participant observation, conversation analysis, user experience questionnaire, concurrent protocol analysis

The methods of data gathering related to the target objectives of the *Explore* module provided insights into the learner's affective state. The methodology of data gathering aimed to capture these responses developing in the learner.

Participant observation and video recording allowed for evaluation to capture the development of affective factors of learning. Video recording was used as a way of recording non-verbal communication, as well as human-computer interactions.

Conversation analysis and specifically Mercer's classification of types of talk was used as a way of analysing the nature of discussion, which develops between learners. Dialogue and discussion were analysed from the point of view of whether they contributed to the development of original or reflective thought in the learner. Further, the purpose of discussion was given particular attention in the sense of uncovering the attitudes with which learners approached the learning content.

A user experience questionnaire was used as a way of triangulating the data gathered through observation on both affective and cognitive aspects of learning. The user experience questionnaire was also an opportunity for learners to express and evaluate the way they perceived their experience with the learning environment.

A further way of evaluating the learner's experience was the use of concurrent protocol analysis. This technique was used in a supplementary way to observation – where learners' actions left their meaning making process unclear.

The following chapter looks in more depth into the methodology and specific methods of data gathering and interpretation which make it possible to evaluate the pedagogical effectiveness and pedagogical responsiveness of the ecoWarrior learning environment.

Chapter 7. Evaluative Methodology for the ecoWarrior Learning Environment

7.1. Introduction

This chapter makes explicit the methodology adopted within the evaluation of the ecoWarrior learning environment. The methods of data gathering and analysis are explained in terms of how they facilitated answering the specific research questions posed in the study.

The evaluation strategy adopted is influenced by the type of learning which the learning environment aims to elicit from students. There are two distinctive types of learning concerned in this case – on the one hand declarative subject knowledge and on the other, the development of creative thought. This necessitates combining two distinct approaches to data analysis and interpretation – grounded theory and discourse analysis.

To make a clear relationship between the type of data analysis technique used and the objectives of the research, the research questions pertaining to each of the approaches to data are once again summarised.

The chapter further discusses how issues of validity of data have been approached through the use of triangulation techniques.

Evaluation strategy

As the research follows an action research methodology it needs to involve a desired intervention into teaching and learning practices in D&T. This intervention is identifying how the following desired changes can be approached:

- change in the learner's attitude towards issues in eco design / towards designing;
- a more autonomous learner;
- an intrinsically motivated learner.

These areas of desired change and intervention are based on the findings of the Learning Needs interviews and the research questions elicited in Chapter 6 (section 6.3.1).

Evaluating the ecoWarrior learning environment allowed me to identify specific conditions of learning which contribute to a change in attitude; a more autonomous learner; an intrinsically motivated learner. These conditions could be design principles, interaction styles, approaches to pedagogy, use of specific media etc.

Evaluating a change in attitude is a complex task. This research approached the task by using a mixture of approaches - grounded theory and conversation analysis. The way the learner made meaning and constructed knowledge gave indications of the process of change in the learner's attitude, just as much as the content of students' conversation did.

On this basis, the evaluation strategy in terms of methodology and specific methods could be established in more detail, as will be discussed further in this chapter.

7.2. Longitudinal study

Longitudinal studies are most commonly used to evaluate aspects of human growth and development (Cohen, 2000(e): 174; Bryman, 2004; Bijleveld, 1998). The ecoWarrior learning environment was used as a tool for observing whether over an extended period of time of using the system, students' attitudes would change. In these terms the longitudinal study was aimed at observing a qualitative change in the learners' attitude towards their own work and towards the issues of eco design and sustainability. As regards their own work, a change in attitude needs to take place in the degree of creative control learners exercise. As was discussed in the literature review, creativity manifests itself as a series of affective factors in learning such as increased autonomy, improved self-esteem, intrinsic motivation. These are all defined as affective factors and are visible under the form of attitude change. Since such change happens gradually and is related to the learner's emotional growth, a longitudinal study concentrating on the gradual process of change was considered to be the optimal approach to evaluation.

A further aspect of evaluation, explored through longitudinal study, was the content of the ecoWarrior learning environment – sustainable design. Learning about sustainability is characterised by a change in the learner's attitude – towards their lifestyle, the environment and their own design work. Using the longitudinal study approach was therefore the optimal way to evaluate attitude change where the issues of sustainability were concerned.

A further reason for using longitudinal study is expressed by Bryman:

'may be more able to allow causal inferences to be made.'

(Bryman, 2004: 46)

In these terms evaluative techniques can be employed to identify the cause for an attitude, which students have for example, or a pattern of behaviour. This corresponds to the objectives of research which, in the questions it posed focused closely on the causes or conditions which played a role in bringing about attitude change and in this way enhancing creativity in the learner.

Jones and Issroff (2005) point to the longitudinal study as the optimum way to study collaborative interactions. Within investigations of collaborative learning the authors emphasise the value of exploring affective development. They maintain that collaborative interactions in school settings can only be understood by considering the context in which they occur, which involves change over time.

Issroff and Del Soldato (1996) suggest that time is a key feature in collaborative learning environments, which support learner motivation. The authors maintain that the nature of interactions changes significantly over time. Therefore the authors are making a case for the need for longitudinal studies where collaborative learning interactions are to be observed.

7.3. Stages of the study

The study was carried out in two different schools. In each school the entire class was used as a sample. Students were asked to use the system as part of their ongoing work for 1 hour, once a week over a period of 1 month.

The cohort consisted of 14 students in total, studying D&T at AS level (fig. 24). Two schools participated in the study, in the case of both the entire AS level group of students participated in the research.

School	Number of students participating	Subject and level of study
School 1	5	AS level, D&T Product Design
School 2	9	AS level, D&T Product Design

Figure 24 Students participating in the ecoWarrior evaluation

Evaluation in the first school allowed me to refine my teaching strategy and find out how the material needed to be delivered in order to have the desired impact. The way in which the learning material was delivered was one of the most valuable findings of the evaluation as will be discussed in Chapter 8. The separation of the study into stages followed an action research methodology where each stage of intervention through using the material in the school was followed by reflection on the outcomes. This approach of iterative cycles of data gathering, evaluation and analysis further corresponds to the adopted methodology to qualitative data analysis – grounded theory.

7.4. Sampling

In the case of this research it has been imperative to observe a very specific sample of students – those studying D&T at A level. This was necessary since research was closely concerned with the authentic activities and thinking processes developing in the subject setting of D&T, as well as with the potential to influence creativity at a particularly problematic stage of students' academic development – A level - and the choice of self-directed project work. A cohort study approach was therefore deemed appropriate Bryman (2004: 46).

It was considered necessary to carry out the evaluation with the entire class, since this meant that the learning experience would take place in its genuine intended setting - the D&T classroom.

7.5. Levels of analysis

Involving the whole class further allowed the research to consider two levels of analysis other than the individual as identified by Smith (in Cohen et. al., 2000(b) : 114) – namely - group analysis and cultural analysis.

7.5.1. Group analysis - the interaction patterns of individuals and groups

The focus of this research on the social construction of knowledge through collaborative work and dialogue between learners (section 6.3.1), made it necessary to consider this level of analysis. While the students were in couples, these pairs did not function as separate from the rest of the group. Rather it was more realistic and closer to the reality of the interactions to see them as part of a community of practice, as described by Lave and Wenger (1991(d): 89). This allowed me to gain an insight into the way the entire group of students contributed to the dynamic of social interactions. The research questions regarding collaborative work and dialogue elicited in Chapter 6 (section 6.3.1, Structuring learning content and learning interactions – approach to learning theory), were explored by analysing these interactions.

To summarise - research had to necessarily focus on the experience which the whole class created, since the whole class was what realistically constituted the community of practice in which pairs of students functioned.

7.5.2. Cultural analysis

Cultural analysis is concerned with the norms, values, practices, traditions and ideologies of a culture. The concern of this research from this point of view was to establish whether the norms, values and practices of the secondary D&T classroom allowed for the interactive learning environment and the learning experience created to become part of the culture, and be effective in producing the desired change in the learners. In particular, exploring the research questions elicited in Chapter 6, regarding the development of learner autonomy, the role of the teacher and the influence of affective factors, made it necessary to consider the cultural level of analysis (section 6.3.1). It was necessary therefore to evaluate the system in the setting of the real life classroom. Such cultural analysis was undertaken only on the level of evaluating through observation how open and prepared students were to accept this comparatively new method of learning, which a computer based multimedia learning environment could offer, and similarly how open and responsive teachers were to the idea of computer-based learning. Teachers' opinions were established through making teachers participants in the observation cycle as well as gathering their opinions ongoing throughout the evaluative sessions. Teachers' reactions and behaviour were observed and conclusions were drawn regarding the effectiveness of combining their teaching approaches with those of the interactive learning environment.

However, a further function of placing a focus on cultural analysis came from the epistemology adopted within research. As Chapter 3 identified, the social constructivist perspective provides grounding for research as a whole, alongside phenomenology (3.4.3). The social constructivist perspective was identified as significant specifically in its concern with the culture, within which the human-to-human and human computer interactions this research is interested in, develops. It was emphasised that while social interactionists saw the culture in which ideas were generated and developed as essential to producing meaning, phenomenology saw the effects of culture as potentially 'crippling'. The focus of the cultural analysis in terms of evaluation therefore in the instance of this research needed to uncover the impact of the D&T classroom learning and teaching culture on the creative learner and the implications within this for the way in which an interactive learning environment was used within such a culture.

7.6. Observation as an evaluation technique

7.6.1. Video observation

Preece, Rogers and Sharp (2002(c)) identify that video observation can be used to capture data such as keystrokes, mouse clicks, conversations. This type of observation can be used to analyse:

- what users do;
- how long they spend on different aspects of the task;
- insights into users' affective reactions (sighs, frowns, scowls - all speak of the user's dissatisfaction or frustration.)

The evaluation of the ecoWarrior learning environment relied to a large extent on video observation data. Research concentrated on:

What learners do – which sequences they used most, what instructional design elements they attributed most attention to; where did they learn the most; Insights into their affective reactions as a way of judging their degree of stimulus / engagement with the system and whether their interactions were deep or surface.

The last point regarding learners' affective reactions formed the most significant elements in terms of a focus of observation. This was necessary due to the previously discussed need to evaluate a change in the learner's attitude. Within this, research was looking for the affective factors in learning being triggered. Therefore learners' affective reactions were a key focus for observation.

The learners' body language was a key focus of observation. These were often taken as an indication of whether students were reflecting deeply on the task at hand or merely free browsing.

Another source of data providing a significant insight into the learner's affective change was the dialogue, which developed between learners and between learners and teacher. Conversation analysis was employed in order to analyse factors such as the nature of motivation of the speaker, the type of dialogue and the dialogic function, which it performed.

To summarise – video observation focused on three key types of interactions – human computer interactions, body language and dialogic interactions between students and between students and teacher.

7.6.2. Participant or non-participant observer?

Preece, Rogers, Sharp quote Colin Robson's (1993) possible levels of participation:

- Complete participants;
- Observants who also participate;
- More marginal participants;
- People who observe from the outside and do not participate

(Preece et. al., 2002(a): 363)

Within this research several factors shaped the degree of participation, which the researcher adopted. Firstly, the nature of the methodology - action research – identified the need for a positive intervention within the D&T classroom. This conditioned an active form of engagement on the side of the researcher in making such intervention possible, adopting the role of teacher and learning technologist in identifying and applying the optimum delivery method for the environment.

A further aspect which determined the degree and nature of engagement for the researcher was the fact that the teacher's role within a learning environment which involved a computer as an active element was not firmly defined. Indeed determining the optimum role for the teacher in an interactive learning setting has always been one of the questions which research aimed to provide an answer for.

In the case of this research therefore a form of intervention in action was applied, which sought to define the ways in which the teacher needed to intervene, the nature of their intervention and even - as we shall see in the results of evaluation – the timing and degree to which such intervention was necessary. Within this the researcher adopted the role of learning facilitator. Alongside this, teachers became part of the observation team, continuously interacting with students and with the learning environment. In terms of the type of observer therefore the researcher as well as teachers acted as a mixture between a participant observer and a complete participant:

'...if the goal is to understand how the computer integrates with other artefacts and social interactions in the classroom, a more holistic approach would be better. In this situation the evaluator might take more of an insider perspective in which she talks to participants as well as observers.'

(Preece et. al., 2002(a): 339)

Since the goal of observation was precisely to establish how the computer integrated with the existing learning and teaching structures in the D&T classroom and what its respective role was within these structures, as well as in what ways it could be used to create a positive intervention, the researcher naturally adopted the role of participant observer. The researcher further took on the role of facilitator of learning by engaging learners in different forms of dialogue at key stages as a way of establishing both their responses to such methods of delivery and the optimum role of the teacher within this.

7.6.3. Lab environment or field study?

Preece et. al. emphasise the difference between data collection carried out in a lab environment and that carried out in a field study:

'In the laboratory the emphasis is on the details of what individuals do, while in the field the context is important and the focus is on how people interact with each other, the technology and their environment.'

(Preece et. al., 2002(a): 364)

The authors also go on to emphasise that this influences how lab equipment would be used - in lab conditions equipment is 'static', whereas in the field it often needs to be moved around.

Since in the case of this research observation was in the field, i.e. the authentic D&T classroom environment, emphasis was on capturing the holistic context within which learning happened and the effects of bringing in a computer in the interactions. Equipment was therefore not static. A single camera was used, which was moved around in order to capture the individual interactions between several pairs of learners as well as any group or individual activity, which occurred.

While the experiment can be more accurately described as a field study, some elements characteristic of a controlled study were also used for gaining a fuller understanding of the learning processes which evolved. The think-aloud technique also known as concurrent protocol analysis is characteristic of controlled environment evaluation:

'The technique requires people to say out loud everything that they are thinking and trying to do, so that their thought processes are externalised.'

(Lindgaard, 1994: 114)

This technique was used as a way of establishing the pedagogical effectiveness of the learning environment – in other words – do students learn as a result of the interactions? Learners were asked to verbalise their thoughts, thus making transparent the reasoning process they were going through when making choices in the system. In this way evaluation helped establish whether learners' choices within the ecoWarrior learning environment were logically informed and gave an indication of the extent to which they understood the content as well as learned from it.

Preece et. al. (2002(a)) further draw our attention to the complexity and rapid change, characteristic of field observations. The authors recommend that a framework of key questions in which the study is interested needs to be developed in order to closely focus the observation as well as to organise the data collection activity.

Considering the nature of this research as tending towards the field study approach, such a framework of guiding questions was necessary to develop. The research questions developed in Chapter 6 was used as a basis for focusing the observation.

7.7. Data analysis

Specific data collection tools used within ecoWarrior evaluation sessions were:

- audio recording;
- video recording - moving camera;
- verbal walkthrough (concurrent protocol analysis);
- user experience questionnaire;
- still photos;

- sketch work;
- note taking;

Two methods of analysis were applied:

- qualitative data, which was interpreted, telling the story of what was observed;
- qualitative data, which was categorised in the tradition of content analysis

Some commonly used techniques for analysing and reporting ethnographic data are:

- looking for key events which drive the users' / learners' activity forward;
- looking for patterns of behaviour;

(Bryman, 2004: 291)

All of these techniques were used within the evaluation of ecoWarrior. The analysis of the learners' use of ecoWarrior focused on critical incidents such as:

- what triggered excitement / stimulus in the learner;
- what triggered dialogue between learners;
- learners revisiting sequences out of their own initiative and free will;
- signs of frustration with the learning experience.

7.7.1. Grounded theory

It is of key importance to this research to support the emergence of new hypotheses. This is essential since while initial categories of research were established through the literature review as well as through the Learning Needs interviews (see Chapter 5) these categories were not in any way conclusive and their validity could only be evaluated through putting the ecoWarrior learning environment into use within the authentic classroom setting. Further, allowing the learning environment to function in its intended setting brings with it a whole new set of factors, which the research has not so far had the opportunity to consider. Amongst such factors are:

- group dynamics and their effect on dialogue development;
- the effects of using of the learning environment over a period of time;

- the effect of teacher intervention at various points in the learning interactions.

This is why the grounded theory approach, already used once in the analysis of the Learning Needs interviews, was considered the most appropriate approach to coding data. The constant comparison method was utilised as discussed in section 4.6.

The use of the grounded theory approach accounts for analysing certain aspects of the learning interactions, such as students' ways of navigating through the learning environment and what this tells us about the degree of their involvement with the learning experience. The research questions, elicited in Chapter 6, regarding user control and autonomy, human-computer interactions and the structuring of the learning interactions were explored through the use of grounded theory.

As regards the dialogue developing between learners – grounded theory helped analyse what students were saying, the content of their conversation. This helped establish the extent to which they had actively adopted the vocabulary of eco design and sustainability within discussions of their own project work for example.

However, grounded theory and the constant comparison approach were not suitable for analysing a key aspect as regards learners' dialogue – besides focusing on what learners were saying, dialogue and collaboration needed to be analysed from the point of view of why learners were having the dialogue in the first place, with what motivation and to what expected result. This formed the most interesting part of analysis and the one which revealed most about the pedagogical effectiveness of the learning environment. Such analysis helped establish the type of motivation with which participants were speaking and on the basis of this identify the potential for original thought, which was created. Such analysis further helped establish the specific conditions and factors which played a part in encouraging learners to be creative in their thinking. It is evident that such insights would not lend themselves to categorisation or comparison – rather an approach to understanding discourse was necessary, such as would fall in the area of discourse analysis. The following section describes how discourse was used to analyse dialogic interactions within the ecoWarrior evaluative sessions.

7.7.2. Analysing discourse

From the point of view of discourse analysis, this research is interested in:

- How do students' attitudes change towards eco design and sustainability as well as towards their own work?
- What are the factors which influence autonomy and independent thought in the learner?
- What are the factors which stimulate intrinsic motivation?

These questions are concerned with psychological changes and are associated with an objectivist viewpoint - the assumption that there can be a change in the learner's attitude and that we can influence this change is positivist. Having said this, the firm focus of this research on affective factors necessitates looking beyond the counting of instances as a methodology. It is concerned with uncovering not only the content of what students say, but also looking into how and why learners engage in dialogue. To a great extent the truly valuable data was hidden in the students' dialogic interactions. In this way research adopted the stance that in some instances we can assess whether the process of change is happening (change in attitude, autonomy in learning) by observing how students constructed meaning in dialogue and interaction. Adopting such an approach suggested the use of discourse analysis. Research questions regarding the role of dialogue and collaboration to learning, as well as the influence of affective factors on learning and creativity were explored through discourse analysis (section 6.3.1, Affective factors which influence learner creativity).

Furthermore, the type of learning this research was interested in was a change in the learner's attitude. To evaluate such change, it was necessary to consider the process of change as an indication of student learning. Discourse analysis can be valuable in uncovering the process of change in students' understanding and attitudes. For this reason discourse analysis was adopted to inform the evaluation strategy.

Conversation analysis

Conversation analysis (CA) is the form of discourse analysis, which most closely corresponds to the objectives of this research. The following section discusses in detail the contribution, which CA made to the evaluation of the ecoWarrior learning environment.

Schiffrin maintains that CA:

'...seeks to discover the methods by which members of a society produce a sense of social order.'

(Schiffrin, D.; 1994: 232)

The capacity of CA to be concerned with how language creates and is created by social order was used in the dialogues, which emerged within the use of the ecoWarrior learning environment as a way of evaluating the changing roles of teacher and learners within the learning setting. This phenomenon is predicted and described by Lave and Wenger who see the roles of teacher and learners evolving as the learner gains confidence in their skills, abilities and knowledge (1991: 89(d)). Being able to analyse this phenomenon was of particular interest to this research since it allowed us to observe how learners begin to negotiate a new social order as they gain more confidence in their role as creative individuals and independent thinkers. Where such a change was indeed observed in the learners' dialogue, this indicated a change in the learner's attitude. CA was relevant in making such change explicit.

The following two sections discuss two characteristic features of CA, which have been of particular significance to this research. These features will be described in view of how they contributed to the aims and objectives of the evaluation of the ecoWarrior learning environment.

Context in conversation analysis

One of the key tenets of the CA approach maintains that in a conversation:

'each utterance in a sequence is shaped by a prior context...and provides a context for a next utterance'

(Schiffrin, D.; 1994: 235)

This is an element of significant interest to this research since it is concerned with how learners develop a shared context in dialogue with each other on which all participants can draw in order to arrive at an original idea or a richer understanding of the topic discussed. Being able to follow how such context develops allows the research to elicit the conditions, the social setting and the factors which make the development of such context possible.

There is a further emphasis in CA on the way each participant in the conversation contributes to the development of shared context:

'what an interactant contributes is shaped by what was just said or done and is understood in relation to the prior. Over the course of an interaction the context continuously changes each contribution provides a new context for the next'

(Pomerantz, Fehr, 1998: 69)

In this way, through using CA, research was able to analyse how each learner or participant in the interactions had managed to contribute individually to the development of a design idea as well as the effect their contribution had had on the other participants.

The author further emphasises the significance of looking at the contributions of each participant individually:

'...conduct helps to constitute the identities of the participants'

(Pomeranz, Fehr, 1998: 70)

In these terms CA allows and advises us to place a focus on the role which each participant plays in the interaction. This is important for the research since in its focus on identifying the optimum roles of teacher and learners within an interactive learning environment research and the analysis of data need to be able to look into the different roles which an individual can adopt within the learning interactions. For example, analysis needs to consider the teacher not only in their role of an instructor but also as an authority figure, as well as a source of expert feedback to learners. Similarly, one learner can adopt the role of the teacher or feedback provider for another learner, as well as being a learner themselves. CA is valuable in this respect in allowing research to consider the variation and shift in roles of each participant in the learning interactions.

The importance of activity

Pomerantz emphasises the focus which CA places on activity as a form of sense making for people:

'how people in society produce their activities and make sense of the world about them'

She further describes the objective of CA analysis as:

'to illuminate how actions, events, objects, etc. are produced and understood...'

(Pomerantz, Fehr, 1998: 65)

This is significant in making explicit the relevance of CA to this research. If we accept that arriving at an original idea – one of the key learning outcomes of the ecoWarrior learning environment – is an action or an object produced through dialogue then CA allows us to understand how such action is produced. It further allows us to gain an insight into the conditions and factors, which contribute to generative thought developing in learners as well as, conversely, to detect any negative factors.

Mercer's types of talk

As a supplementary approach to CA in the analysis of dialogue emerging within the ecoWarrior learning environment, Mercer's classification of talk into distinct categories was also used (section 2.1.4). It provided a system for understanding how learners negotiated meaning and the extent to which their conversation had potential to develop into an original idea. By placing Mercer's classification into a CA structure, data analysis could focus on the internal and external factors and conditions, which acted on the situation and the way this impacted on the learning outcome of the conversation – whether this was a shared new understanding or an original idea.

7.8. User experience questionnaire

Alongside the qualitative approach to data, which this research adopted through discourse analysis and grounded theory, a quantitative method was employed. A user experience questionnaire was distributed to students aiming to gather feedback on their experiences of using the learning environment. A form of methodological triangulation was employed by using different methods on the same object of study. As Cohen et. al identify the most commonly used and effective way to triangulate data is to combine a qualitative approach with a quantitative one. Generally, the more the methods contrast with each other the greater the researcher's confidence in the validity of the study (Cohen et. al., 2000(b): 113).

Triangulation was a secondary function of the user experience questionnaire. Its primary aim was to give participants a voice and the opportunity to express how they felt about ecoWarrior as a learning experience and as a tool for progressing their own understanding and knowledge.

Lindgaard differentiates between two types of information, which a questionnaire can aim to gather – objective and subjective. In this research, aiming to establish participants' perceptions of the learning environment as an educational experience, the focus is on subjective data, concerned with the *'opinions, knowledge, feelings and predictions of a particular population'* (Lindgaard, 1994: 162).

The questions of the user experience questionnaire were derived directly from the research questions formulated for the study on the basis of the literature review as well as the findings of the Learning Needs interviews (see Chapter 5).

In this way the *Case study module* aimed to evaluate how well the interface and the game design metaphor worked in terms of enhancing stimulus, learning of concrete concepts, developing an intuition (see Appendix 7, Part I, questions 1 to 6).

The second part of the learning environment – *Two players module* - had a different goal. It aimed to evaluate the extent to which students were able to learn through dialogue; the extent to which they were able to carry the content they were exposed to out of the artificial situation of the game and into their real project work (see Appendix 7, Part II, questions 6 to 8, 13 and 16).

The third module – *Explore* – aimed to evaluate the extent to which the system was able to enhance learners' potential for creative expression (see Appendix 7, Part II, questions 1 to 3, 5, 9, 11, 14, 15 and 18).

Students were asked to fill in a user experience questionnaire at the end of each session. This allowed the questionnaire to take advantage of the longitudinal study approach of the evaluative strategy as a whole. In this way the responses of learners could be considered from the point of view of whether there was a difference in response in the first session as compared to the last session. This contributed to an understanding of whether and in what way learners' attitudes towards the subject had changed.

7.9. Pilot study

Pilot testing of the ecoWarrior learning environment was carried out with students from Sheffield Hallam University. Initial contact was established through an advertisement for project help posted to the University students' forum. Six students participated, four with design experience and two with knowledge of computer aided learning.

The purpose of the pilot study was primarily to establish whether dialogue between two learners occurs while interacting with the learning environment, and whether this dialogue constituted meaningful learning.

Another consideration of the pilot study was to observe how well the interface worked in terms of being stimulating as well as in promoting learning.

A further focus was placed on observing whether the sketching tasks in the Explore Module worked, in terms of making learners think about their work from a different perspective, as well as evaluating whether the way the task was worded could encourage learners to sketch in the first place.

7.9.1. Findings of the pilot study

The pilot study made a number of recommendations regarding usability issues in the system. Following is a brief overview of some examples of changes, which were made as a result.

Usability issues

The initial version of ecoWarrior offered audio descriptions of the eco design concepts' meaning. When played from several computers simultaneously the voiceover became too obtrusive and permeating to the point of distraction. As a result the system was altered to include a textual description as an alternative to the voiceover.

Participants discovered the game rules section without difficulty however not everything was clear in the description it gave. One pair only read the rules very quickly and jumped into playing the game. As a result they misunderstood the rules and started dragging the wrong concepts as well as the right ones to the boxes – even though the rule clearly states that only correct concepts should be dragged. As a remedial measure the 'game rules' help screen was redesigned in its content; in addition interactive features were added to allow for enhanced comprehension.

Affective response

The learning environment managed to create the necessary stimulus for participants to fully engage with its content. Participants expressed joy when they guessed right and disappointment when their choices proved wrong. When one of the pairs lost the game of the *Marble table,* they returned to the home page to select another product, but they selected the same one – with the words:

J *Go on - lets get it right.*

It was clear from the comment that their motivation for going back to the game was that they wanted to win. At the same time, through repetition they were able to learn the concepts' meanings. In this instance the value of games design to learning received a proof in its capacity to enhance comprehension and retention.

Collaboration

The pilot study was essential in monitoring whether the element of collaboration would plausibly develop in learners using the learning environment. While the modules and most media elements, structural and interactive elements within ecoWarrior were aimed at promoting dialogue and discussion between participating learners, there was no guarantee that students would in fact respond to the system in a collaborative way. It was essential therefore to pilot the system in view of observing whether dialogue and collaboration would develop.

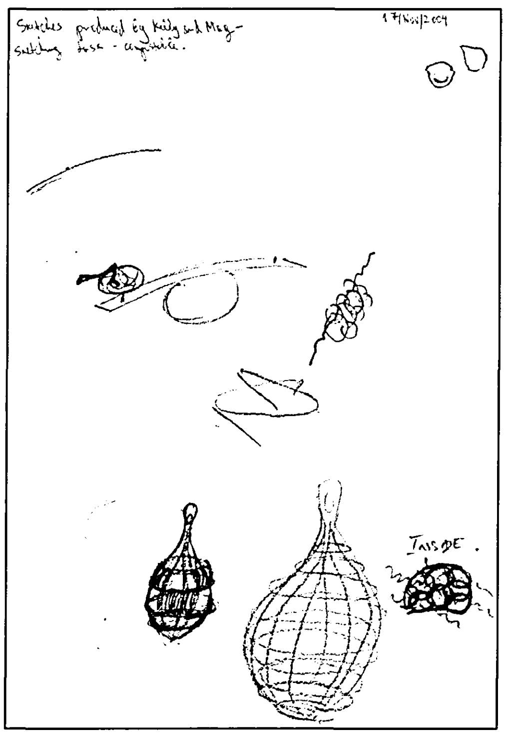


Figure 25 Participants' sketch responding to the sketching task

Participants in the pilot study responded well to collaboration and took to the idea of sharing control of the learning environment very naturally. In the Case study module interactions there was clear evidence of the participants collaborating with each other, negotiating and giving reasons for their choices.

One pair of participants achieved good progress with one of the sketching tasks (fig. 25). They were working with an image of their own work. The two participants came up with and sketched at least two new solutions. The pair successfully collaborated on the sketching task, discussing possible solutions.

The findings of the pilot study provided guidance to the further evaluative study in several respects. Firstly in giving an indication of some issues which needed to change in order for the learning environment to be pedagogically responsive in a classroom setting. Secondly they gave some reassurance that the learning environment design could afford for collaboration and dialogue to develop. Finally, they gave an indication that it was possible for a creative response to develop with the aid of the ecoWarrior learning environment.

While none of these could be treated as definitive findings, since the participant group was not fully representative of the actual cohort of A level D&T learners, the indications which the pilot study gave were sufficient to confirm that the ecoWarrior learning environment was sufficiently developed to be used with A level D&T students.

7.10. Summary

This chapter has made explicit the methodology adopted within the evaluation of the ecoWarrior learning environment. The significance of using a longitudinal study was emphasised in allowing research to be able to make qualitative judgements on the changing attitudes and developmental processes in the learner.

While the methods adopted within data analysis stem from fundamentally different theoretical approaches – with conversational analysis belonging to socio-cultural linguistics and constant comparison from the grounded theory approach and phenomenology, this chapter has given strong reasons for the presence of both approaches within the evaluative strategy of ecoWarrior.

In addition to the two qualitative methods of data analysis, a quantitative, questionnaire based approach was described which provides a mode of methodological triangulation as well as allowing learners to express an opinion on their experience with the learning environment.

Finally, the chapter described the pilot study preceding the actual learning environment evaluation in secondary schools. The pilot study's findings and the changes, which it necessitated, were discussed from the point of view of the impact they had on shaping the evaluation strategy.

The following three chapters discuss in detail the findings of the evaluation of the ecoWarrior learning environment.

Chapter 8. Analysis Part 1 – Factors Influencing Learner Autonomy

8.1. Introduction

This chapter explores the key issues identified in Chapter 6. These issues can be described as the external factors which influence learning.

Firstly, exploring issues of learner control suggests navigation has a significant role in reinforcing learner autonomy and self esteem.

Secondly, types of dialogue within a computer-based learning environment are explored, considering which is most likely to reinforce an attitude of reflection and inclination for creative thought in the learner, including the role of the teacher in such dialogue. Positive and negative instances of teacher intervention led to conclusions on the degree, nature and timing of teacher intervention.

Further, the role of collaborative discussion is reinforced as a pedagogical factor of considerable significance, where learner-to-learner dialogues result in some of the most creative and original ideas in the ecoWarrior evaluative sessions. Within this a 'listening approach to the use of dialogues' is observed (Cook, 2002 : 6), which reasserts the importance of face-to-face collaboration with its possibilities for flexible and uninhibited discussion to develop amongst learners.

8.2. Navigation and autonomy

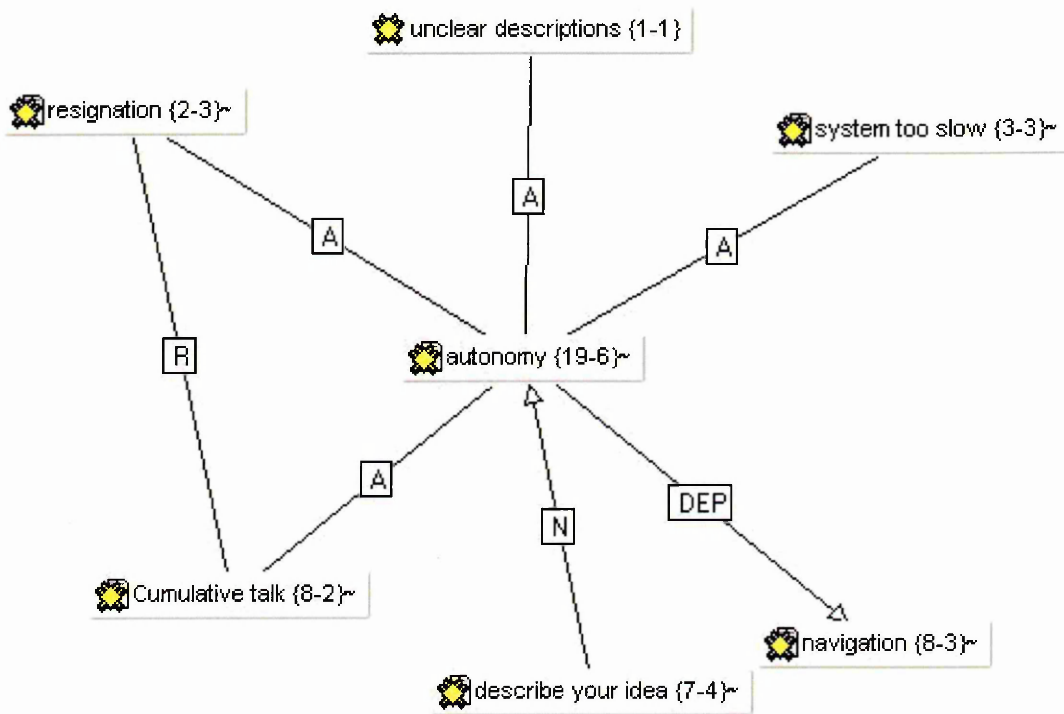


Figure 26 Autonomy depends on navigation

The semantic network shows clearly that one of the factors influencing learner autonomy is how well the navigation tool works.

This section explores the relationship between the pedagogical responsiveness of the navigation tools in the learning environment and affective factors in learning.

In Chapter 6 the question of learner control was posed:

- How should the issue of learner versus system control be resolved in the learning interactions in order to support learner autonomy?

Whether the learner is autonomous in their interactions with the learning environment depends on how successfully the navigation tool works (fig. 26). Several instances were observed where the tools for navigation did not manage to support the learner in finding their way around the system. In the following instance the relationship between the use of the navigation tool and lack of autonomy in the learner becomes evident:

School 1, Session 1

Student: *So what do I have to do - click on them?*
Researcher: *Well these are the main areas and this is also a navigation section.*
L. looks at the 'compostable products' section. *He does not find out he has to click on the existing products so he asks:*
Student: *How do you go back?*

The way to use navigation had not been sufficiently obvious, which induced the learner to refer to the teacher for guidance:
'So what do I have to do – click on them? ... How do you go back?' The fact that the learner had to refer to the teacher for guidance undermines the possibility for independence on the side of the learner.

As Merrill argues, giving learners control over the interactions allows them to discover how to learn (Merrill, 1975). In this way learners acquire knowledge of learning strategies, which they can use further in self-directed learning. As was discussed in Chapter 2, self-directed learning is integral to the nature of constructivism and is related to learner autonomy. Further, knowledge of learning strategies allows learners to act free of the influence of an authority figure and function within a non-authoritarian environment, which has already been discussed as a favourable condition for creativity (see section 2.2.1).

So it is evident that navigation relates directly to the development of autonomy in the learner. Learners would only have the opportunity to be autonomous in their interactions if they felt they were in full control of the system. One of the factors influencing this feeling of control is how well the navigation tools perform.

8.2.1. Navigation as an evaluation tool

Apart from its relationship to autonomy and level of control, the use of navigation by learners is further indicative of the depth of the learning interactions. Using Garrett's classification (Garrett, 2003), three distinct types of navigation can be identified within the ecoWarrior learning environment:

- The next-back buttons;
- Global navigation by topic (ex. 'Solar cooker', 'Solar lantern', 'Solar thread', each of which explores a different aspect of solar power);
- Global navigation by function (ex. 'Introduction' – 'Main topics' – 'Summary').

The next - back buttons guide the learner through the sequence in a linear way, going through introduction, all the interactive and narrative sequences and sketching tasks.

Following is an example from School 2, Session 1 where learners are applying a linear approach to navigation – using the next – back buttons. This is proving to be indicative of the depth of their exploration:

School 2, Session 1

Observation: *Learners C and J use the 'next' - 'back' buttons rather than the list of headings to navigate through the 'Explore' sequence. This indicates that they are following a linear progression, suggested by the system rather than discovering what they themselves are interested in and finding their own patterns of content selection according to their personal interests.*

Evidently, the way in which navigation is being used by learners, has implications for the learners' autonomy. In this instance learners chose to use the *next - back* buttons, which prescribe a linear progression through the exercises. Choosing a linear form of interaction with the system indicates that learners are content to allow the computer to guide them through the interactions rather than finding their own paths through the sequence. This indicates that the learning material has not yet become personally relevant to the learners. If students perceived the learning material as personally relevant, and directly related to their own project work, if they had interests developed already and questions, which needed answering, they would be selective with the kind of information they looked for within the interactive sequence. Further, they would not be inclined to be guided in a linear progression but would rather find their own paths and establish their own interaction patterns.

This analysis is supported by Boyle, who maintains that linear progression is a mode of interaction, which can be associated more closely with novice learners or beginners (Boyle, 1997). The question is - is this surface type of interaction a result of being unfamiliar with the system or is it a result of students not finding the learning material personally relevant? Since the observation discussed above was made in the first session of evaluation, affordances can be made for both answers. However it should be possible to answer this by the end of the fourth session, when learners should have had sufficient time to fully familiarise themselves with the system and should have begun using it intuitively.

The following is an example from Session 2, School 2, which shows how learners are already starting to change their attitudes and becoming selective with the content they view and react to:

Session 2, School 2:

Observation: *Camera moves on to learners T and C. They are looking at the solar headphones. They spend a long time on this page. They open the sketching task and read it. They do not like this task and move on to the 'solar cooker' page. They read this task. T. and C. then move on to the solar cooker web page and look at the solar cooker case study.*

T: *Let's look at the diagram.*

The two learners are interested in the construction of the solar cooker. T. is sketching while C. is reading the information on the website carefully.

T: *Instead of using a light - use a reflector.*

In this instance a marked difference was observed in the way learners navigated through the information. Their path of navigation showed signs of narrative construction, which as identified by Plowman et. al. (1999) and Laurillard (1998) is an indication of meaning making in the learner. It is therefore possible to conclude that the students are learning and further – that they are choosing their navigation paths to reveal more about the narrative they are interested in, not the one prescribed by the system.

8.2.2. Navigation as a way of establishing personal space

Bekier sees navigation as an opportunity for learners to establish *'their own cognitive space'* (Bekier, 2005). He sees this as a higher function for navigation to that of *'providing pathways through content'*. According to Bekier, the claim that navigation supports learning can only be made if learners have managed to establish their own cognitive space within the system. Within evaluating the ecoWarrior learning environment the condition of whether learners have managed to establish their own cognitive space can be evaluated by observing the way in which learners navigate. This section explores the questions posed in section 6.3.1 - *User control and autonomy*. These are questions, which can be used in understanding how the learners' use of navigation can be used as an indication of the extent of their learning.

The following observations made in the fourth session in School 1 shows how learners have begun to display a preference for much more advanced forms of navigating through the system:

School 1, Session 4

Observation: *After having explored the system to some detail, they go to 'Outdoors*[6] *again. Then to 'Extreme wear'. Then to 'Manufacturing'. Then to 'Anti-fashion'. They do not stop at any of these because they have visited them previously, before completing the quiz.*

In this instance learners were using navigation by topic to revisit and summarise the sequence, making sure they had not missed anything and further - arranging the information once again in their minds, thus creating a mental map of it and ensuring they have remembered all relevant information. This form of quick browse-through is a useful tool for internalising learning for the student, and allows for the creation of a cognitive map by the learner where they assign a space to each significant part of learning content. The fact that they engage in

[6] 'Outdoors', 'Extreme wear' and 'Manufacturing' are the headings of each of the main topics, which the 'Durable' explore sequence covers.

this activity shows willingness to internalise and remember the content. This was a positive indication that learners found the information personally relevant, therefore they made the effort of going through the sequence again in order to construct a mental image of its content.
This places an emphasis on designing the navigation tools in a way, which would support this process of cognitive mapping as fully as possible, since the learner's ability to summarise and draw conclusions from their exploration depends on the ability to construct a mental map.

As compared to the learners' use of navigation in the first sessions, this form of navigation which allows them to perform higher order thinking tasks – internalising new knowledge– is indicative of learners having managed to progress significantly in the ways in which they use the learning environment. The interactions are now being related to the learners' past knowledge and experiences, which is apparent from the fact that they try to recap and reiterate in order to memorise the information.

Therefore the question posed earlier of whether the surface type of interaction displayed by students is a result of them not finding the learning material personally relevant, can be answered in a positive way – the learning material does interest the learners and their initial caution in the interactions can be put down to being unfamiliar with the environment.

Guideline - Navigation and autonomy

Autonomy and navigation are closely interrelated within the use of a learning environment. In order for learners to develop independence in their thinking they have to be able to take control of their learning interactions. This could only happen if the navigation tools are sufficiently well designed.

In terms of navigation, the learning environment should afford for learners to choose their own paths of interaction. The way in which they construct sequences to view within the learning environment needs to be the learner's choice and be driven by their personal interests. Thus learners would be expected to focus their attention on aspects in the environment where their own interest is focused rather than browsing through in a linear fashion.

The way in which learners use navigation tools within the learning environment can be used as an evaluation tool in determining whether students are learning. If learners are showing independence in their choices of interaction paths this is an indication that they are becoming autonomous and free thinking as well as that they have started seeing the relevance of the issues they are exploring to their own work. This in itself means that students have started to situate their learning within a real world context (Laurillard, 2002(d): 11).

We can look upon the type of navigation, which learners use as a way of determining whether they are relating knowledge in the system to their own work and their own patterns of thinking, whether they are making knowledge their own and if the learning content is personally relevant to the learners. If the learner is making learning their own this is a powerful indication of a change in their attitude, which is one of the key aims of the ecoWarrior learning experience. It means that learners have understood not only what a concept such as 'sustainable energy' means but also why is it necessary, and how it can be used within project work. It would mean they have truly situated learning.

The choice of navigation can be interpreted as:

- Next-back buttons - if this form of navigation is used exclusively by the learner and learners fail to show progression to using other forms of navigation this indicates that learners are allowing themselves to be led through the interaction by the computer and are not actively choosing their own paths of interaction, consequently failing to make meaning. This shows the lowest level of engagement and means that learners are either novice users of the system or that they are not finding content personally relevant. In terms of attitude change and creativity – the use of the next-back buttons on its own has little potential for supporting the development of independent, original thought.

- Global navigation by function[7] (ex. 'Introduction' – 'Main topics' – 'Summary') - would mean that learners are tying to get an overview of the content in the learning sequence in its entirety. It is a good way for

[7] Types of navigation based on Garrett (Garrett, 2003)

navigation to aid reflection. Once they have gone through the sequence, if they use the main function menus as navigation this generally means they are trying to recap, summarise and construct a cognitive map of the content viewed. This technique helps them to memorise and internalise knowledge.

- Global navigation by topic (ex. 'Solar cooker', 'Solar lantern', 'Solar thread', each of which explores a different aspect of solar power). Where a narrative construction is evident in learners' navigation patterns, this is an indication that learners are engaged in active meaning making and are on their way to make this knowledge personally relevant. Learners choose the parts in the sequence, which interest them and place these to the forefront of their reflective thinking. Navigation by topic is an indication that learners are situating their learning and making it personally relevant.

8.3. Factors influencing learner autonomy

The relationship between autonomy and navigation, explored in the previous section, leads us to consider other factors, which have an influence on learner autonomy, such as external intervention by a teacher. This section uses a form of conversation analysis, which provides insights into the complex relationships which influence meaning making in the learner. In these terms dialogue is seen not only as a tool for meaning making but also as having an influence on learner autonomy and self-esteem.

The following dialogue exemplifies students' dependence on the researcher to instigate their interactions and give them direction, as well as comment on the meaning and the outcome, which should be expected. The general attitude, which seemed to develop in School 1, Session 1 was that students were unwilling to find out for themselves what they needed to do but were rather more inclined to ask the researcher for directions.

Alongside new issues, which emerge through the grounded theory approach to data analysis and interpretation, the following questions posed in section 6.3.1, are answered:

- Is the computer capable of triggering dialogue in learners?
- Is the dialogue valuable (deep) or surface?
- What are the specific conditions – type of media, style of interaction, etc, which make such dialogue possible?
- Does the system support ideas being generated in dialogue?
- Does reflective thought develop in dialogue?
- What should the relationship between learner and computer be in terms of forms of dialogue?

8.3.1. Teacher intervention and autonomy

School 1, Session 1

L is reading the description of the 'biopolymer' light. It is evident that he is reading carefully, because he is moving the mouse slowly over the text.

Researcher: *May be if you choose one of these...*
L: *All right - so what do I have to do - just pick one?*
Researcher: *Yes and then do the sketching task. Which is the bit in pink.*
L: *How do I click on to it.*
Researcher: *You don't - it's just this. If you have any ideas. If this one doesn't apply then one of them will.*
L: *I think that one does (He picks the biopolymer light. This is an appropriate choice since his product uses plastics, and he could adapt it to be using a biopolymer.)*
Researcher: *Yes I think so too. Do you want to do a quick sketch?*
L: *Yes I can do.*
(He is reading the task carefully.)
L: *What am I sketching?*

The student was displaying lack of autonomy. In this case his difficulty in finding his own paths of engagement with the material was not a matter of any shortcoming in navigation design, but rather a habit – a pattern had been established in the interactions between researcher and students, where the researcher as participant observer was available to explain what each step constitutes and the learner felt it was natural for him to ask: *'What do I have to do?', 'How do I click on it?', 'What am I sketching?'* These are all decisions, which the learner should be able to make for himself; however he was reluctant to do so, because of the presence in the learning setting of an authority figure and guidance provider.

This phenomenon of lack of autonomy as a result of the presence of a teacher / guidance provider was evident in a number of examples throughout the evaluative sessions in both schools. The teacher's role in the interactions as well as the learner's response to teacher intervention was most evident in the dialogue, which developed between them. Mercer's idea of dividing talk into categories of disputational, cumulative and exploratory (Mercer, 2000(a)) was adopted as a way of understanding the extent to which learner to teacher dialogue had potential for the development of original thought.

In the course of analysis patterns of conversation started to emerge. In mapping talk in this manner it becomes apparent where the concentration of exploratory talk is. As was discussed earlier, exploratory talk is the type most closely associated with, and most productive of, creativity and original thinking. This makes it possible to draw conclusions about what the circumstances are where exploratory talk could develop successfully. Similarly a concentration of disputational talk could be an indication of learners being defensive and acting under the influences of extrinsic motivation, which are known to be factors hindering creativity (Hennessey and Amabile, 1988). The application of Mercer's model was further focussed on establishing the conditions under which exploratory dialogue was more likely to occur, and allowed for conclusions to be drawn regarding what the inhibiting factors to learner autonomy were.

School 1, Session 3 [8]

The conversation described below took place between teacher and learner during Session 3 in School 1. In this instance the teacher was giving feedback on the learner's ongoing work:

[8] **Legend:**

E: Exploratory talk - engage critically but constructively with the other person's ideas
D: Disputational talk - speakers aim to defend themselves and assert their position at any cost
C: Cumulative talk - speakers support and reinforce each others' point of view

Session 3, School 1 **Participants: Teacher Learner L**			
Teacher:	*L., what makes yours different from the ones you can buy in the shops?*		Exploratory - Poses an issue
L:	*That's what I mean that's why I'm unsure about it.*		Disputational - assumes a defensive position
Teacher:	*A bit far down the line to start being unsure about it.*		Disputational - confronts the student about his uncertainty.
L:	*I'm thinking of making the shape different to what is available on the market. 3D shapes.*		Exploratory – tries to offer a solution to the teacher's argument.
Teacher:	*And do you want to make it attractive to young people?*		Exploratory, but also leading and suggestive about directions of thought the learner needs to adopt.
L:	*Yep.*		Cumulative. Agrees with the teacher; but not exploratory – does not offer his own solution of how it will be made attractive to young

			people.
Teacher:	*Why?*		Exploratory – asking a question, although 'why' can also be interpreted as a confrontation / disputational remark.
L:	*Because it's going to be in their rooms.*		Exploratory – offers a solution to the question posed.
Teacher:	*But do you want to draw attention to the fact that they've got an alarm in their rooms? Or is it specifically for adults?*		Disputational – the teacher is leading the learner's thought by suggesting that the alarm shouldn't attract attention.

L:	*More for adults but it's also going to be in children's rooms so…*		Cumulative. Tries to agree with the teacher by picking up on her words ('Adults'), but also exploratory – makes a decision.
Teacher:	*If you are going to make quite a few of them, what sort of production processes or manufacturing do you think might be appropriate and why?*		Exploratory
L:	*Moulding.*		Cumulative
Teacher:	*Why?*		Disputational – does not engage constructively with the learner's response but questions in an argumentative manner.
L:	*Because it's easier to make …*		Disputational. The learner is defending himself.

Teacher:	*So you want to look at batch producing. And you want to put that in your folder work and mention the fact that you can batch produce all the cases – a series of different cases possibly with a different element to each one of them it might have – might be double skin vac forming – you might have one layer and another layer on top and then cut away at the top layer. It might be using foam – this is what you should have looked at already. All the different ways of manufacturing a casing. So what you need to think about now also is – next time you are in the workshop – get the materials out and start to practice – vac form – you know the funky foam – plastazote – vac form that – it makes a really nice –sort of soft look to it. You can press form. You can make male-female mould. And you can heat some foamex up in the oven – those are all the things you need to have done, and mentioned in your folder work. So write that down because I know we are going to have to go back and revisit some of those areas aren't we.*		Disputational- The teacher is telling the learner what choices to make.

Of particular interest was the distribution of cumulative, disputational and exploratory talk. This teacher-to-learner dialogue ended in a flurry of disputational talk (marked in red). This is significant, since it was in marked contrast with learner-to-learner dialogues observed, which will be discussed further on in this section. Within learner-to-learner dialogue the interactions went through a stage of exploration and dispute, but ultimately ended with cumulative exchanges – i.e. – the dialogue ended on a note of mutual agreement and reinforcement of a truth that learners had arrived at through discussion. This indicated that the two learners ended up agreeing on a solution. In contrast, in this case, the teacher ended the discourse with a series of disputational remarks. Instead of going from exploration into an agreement built on mutual understanding and constructed meaning, the dialogue shifted more explicitly towards the teacher interrogating the learner with the purpose of bringing out into the open what the learner has failed to achieve. This placed the teacher in the position of having the authority to tell the learner unequivocally how to proceed with his project in order to bring it to a successful conclusion.

This is not a constructivist approach, since the teacher is seen to lead the process in an authoritarian way. Moreover this type of approach has the negative effect of undermining the autonomy of the learner by making them feel less in control of their own learning and ultimately stifling any potential for original thought and creative risk taking in the future.

While there is no guarantee that the learner would have exercised autonomous behaviour if the teacher had not intervened in an authoritarian way, it is evident that the approach which the teacher adopted did not work towards promoting autonomy or creativity. The constructivist principle of the teacher as a facilitator of knowledge, not an instructor, needed to be applied in this case.

8.3.2. Teacher motivation as a factor affecting autonomy

In the analysis of such dialogue the factors, which motivate the teacher to act in this way also need to be considered.

The dialogue between teacher and learner described above culminated in disputational talk. The teacher knew what answers she wanted to hear and when the learner failed to deliver these answers she offered the answers herself, thus directing the learner's thought in a strong, definite direction.

The approach, which the teacher adopted with the learner, was identical to telling what needed to be done, which is characteristic of the instructional design, behaviourist tradition of learning. Part of the reason for the teacher adopting this hard-line approach was that students were quite far ahead in their project and rather than creative ideas what was needed at this stage was a definite outline of the design process ahead, which would lead to a successful completion.

Further on in this particular student's interactions with the learning environment we could see that he was taking on board what the teacher had said and was adapting his mode of thinking about his project outcome in order to satisfy the teacher's requirements. Such an approach to teaching is evidently detrimental to autonomy. However by knowing the reasons for such attitudes from the teacher and learner, suggestions can be made about how to engineer the conditions and factors for learning in an optimum way:

1) Avoiding constraints in time. This relates to the timing, in which the ecoWarrior learning environment was delivered - midway through a short project, where the pressure to advance with the project and bring it to a successful completion fast is imperative and there is no space for creative exploration. Since the aim of ecoWarrior is to aid the learner in research and idea generation, introducing it to learners midway through a project is unsuitable. A better time for delivering ecoWarrior would be before students have started a project and are actively searching for possible contexts to work within.

Alternatively - if the learning environment is to work as a learning aid throughout the design process it will need to incorporate elements, which support this process. For the learner to take on board and be able to implement the ideas of sustainability in their project work they should be given enough time for the knowledge and experiences with the learning environment they have been exposed to, to take shape and pass from the mode of reflection to the generative mode of thinking.

2) External motivating factors. It is also necessary to consider the teacher's motivation in acting in an authoritarian way. The teacher is responsible for learners delivering high quality assessable work, which would achieve the necessary marks and have implications for the school's performance in league tables. All of these are factors characteristic of extrinsic motivation, which fail to promote creativity and original thought. It is possible at this stage to posit the hypothesis that a similar type of discussion would have a different outcome if it occurred between two learners. Such a hypothesis rests on observations made within the evaluative sessions that learners act on different types of motivation from the extrinsically motivated approach evident in some teachers. As a result, in providing feedback to each other, a pair of learners would be more likely to be guided by what makes an interesting and original solution rather than by what is plausible in terms of league table results.

The following are several examples of dialogues occurring between learners, which provide evidence for this hypothesis. The dialogues are analysed by applying Mercer's classification of talk as a way of identifying opportunities, which the conversation offers for creative development. What makes them even more interesting is that each of these dialogues has originated as a direct result of interacting with the ecoWarrior learning environment. These dialogues allow us to observe:

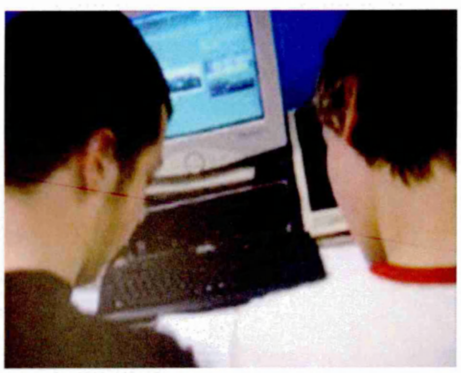
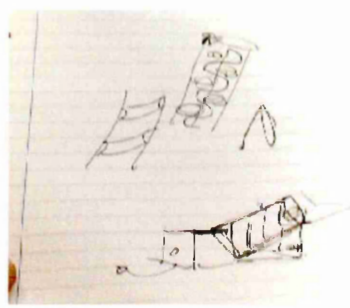
- How and why learner-to-learner dialogues differ from learner-to-teacher dialogues;
- How the intrinsic motivation of two learners allowed to be expressed in a non-authoritarian learning environment works to inspire original thinking;
- What is the role of the multimedia learning environment in contributing to this and in forming the necessary conditions of learning.

The first of these examples is an idea for a compost bin, which learners started to explore as a result of interacting with the Explore module, section

'Compostable' within ecoWarrior. For purposes of clarity this dialogue will be referred to as the 'Archimedes Screw idea':

<table>
<tr><td colspan="4">Archimedes screw idea, School 2, Session 1

Participants:
Learner A
Learner B

(supporting video and audio material available:
see Appendix 5,
ArchimedesIdeaImage.mpg
and
ArchimedesIdeaSound.mpg)</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>A:</td><td>This is your 'power' idea and I said you have to have an Archimedes screw in it.</td><td></td><td>Exploratory - suggests improvement to initial idea by B.</td></tr>
<tr><td>B:</td><td>Ok, well - how about (starts drawing) we've got...I'm trying to think how we could...</td><td></td><td>Exploratory and cumulative: Agrees and elaborates on idea</td></tr>
<tr><td>A:</td><td>You can have a screw idea.</td><td></td><td>Exploratory – suggests an idea.</td></tr>
</table>

B:	*Yes, I think that's something that would work*		Cumulative - agrees
A:	*You only have to think about how it's going to be powered.*		Exploratory – poses a new issue
B:	*You just turn it by hand.*		Exploratory – offers a solution
A:	*Where is the air coming through? The only thing is the compost in fact should be heated from the outside.*		Disputational and exploratory – questions the solution.
B:	*That's not the point we are not trying to compost it really... The problem with the normal compost heap is all the juices go to the bottom. But they can be trapped in each section of the screw like that. (shows on the drawing)*		Disputational and exploratory: draws the focus of attention on a problem he is interested in.
A:	*How do you get it out though?*		Exploratory – poses a new issue
B:	*Hmm...OK how about – you could have like a mesh at the bottom. So when the screw turns over through the mesh and then the water – you can still have the water coming out here, and you could have a box at the end here...*		Exploratory – constructs a solution to the problem posed.
A:	*And is the box here though, so it only allows a certain amount in, so if it's filled you can't...*		Exploratory: Elaborates on the solution adding more detail to the design solution.
B:	*What we were to say is that every time*		Cumulative: Starts to redescribe

	you do a load, you just put a load in …		the design solution – cumulative talk aiming to reinforce the idea they have arrived at and to make sure nothing has been missed
A:	*Yes.*		Cumulative: Agrees and reinforces the idea.
B:	*So you've cut the grass, you empty the grass thing into it, you then turn the handle… (drawing) … there, and spin that round once so it goes down to the bottom, then progress on to the next level.*		Cumulative: Redescribes and reinforces the idea.
A:	*Yes*		Cumulative: Agrees and reinforces the idea.
B:	*And then next time you put the next load in - turn the handle – and you've got the next level.*		Cumulative: redescribe the idea adding detail, agree and reinforce.
A:	*You could have a bit of storage cause –*		
B:	*Yes. And then I guess it would come out in some bin at the end. And the idea would be that by the time it actually got there it would already be composted.*		Cumulative: redescribe the idea adding detail, agree and reinforce.

Several interesting phenomena occurred within this dialogue. Once again the distribution of exploratory, cumulative and disputational talk was significant. Learners started with cumulative exchanges, where one learner explained his idea to the other. This progressed into a mixture of exploratory and disputational remarks. Within this the role of the learner who has had the original idea (learner B) was to defend his solution and the role of the other learner (learner A) was to challenge this idea and offer new perspectives for consideration. The danger with such dialogue was that learner B may have withdrawn to a defensive position where he would be blindly defending his point of view and would not be open to new solutions or suggestions coming from learner A. It was reassuring to observe however, that this did not happen. Within learner-to-learner dialogues both participants were open to being challenged and open to exploring new perspectives of thinking.

There is a fundamental difference between this type of dialogue where one learner has adopted the role of challenging the idea and the type of dialogue, which took place between teacher and learner. The difference comes from both participants being learners, and therefore neither having authority over the other. In this way both learners work on an equal level, and their exploratory talk is much more likely to culminate in generating creative ideas than it would be if the dialogue took place between a teacher with authoritative control and a learner.

The hypothesis emerging here is that if the two participants are both learners, the equality of the relationship, which develops is more likely to have original creative ideas as its outcome than if one of the dialogue partners was in the position of authority, as was inevitably the case with learner-to-teacher dialogues.

Similar ideas were expressed in research literature by Hennessy and Murphy, who also place an emphasis on learner-to-learner interactions where creative problem solving is concerned (1999); Vass who identifies the value of the spontaneity and humour within a friendship pair specifically in enhancing creativity (2002); and Issroff and del Soldato who place an emphasis on *'social affinity between partners'* as an affective factor, which facilitates learning (1996). Collectively, such research points to the value of learner-to-learner dialogue and interactions in opening possibilities for creativity and meaning making.

However, placing an emphasis on learner-to-learner interactions does not by any means devalue the teacher's role. Rather it moderates and reassigns it to a different stage in the learning process. As will be discussed further, there are specific stages in learning where feedback from the teacher is necessary in giving validity and reaffirming what learners have already formed as their own creative ideas.

In support of the argument for the capacity of learner-to-learner dialogue to lead to creative thought, the user experience questionnaire indicates that learners themselves find that dialogue with each other is productive in terms of idea generation. The question was posed as:

'How did discussion with another learner affect your performance?'

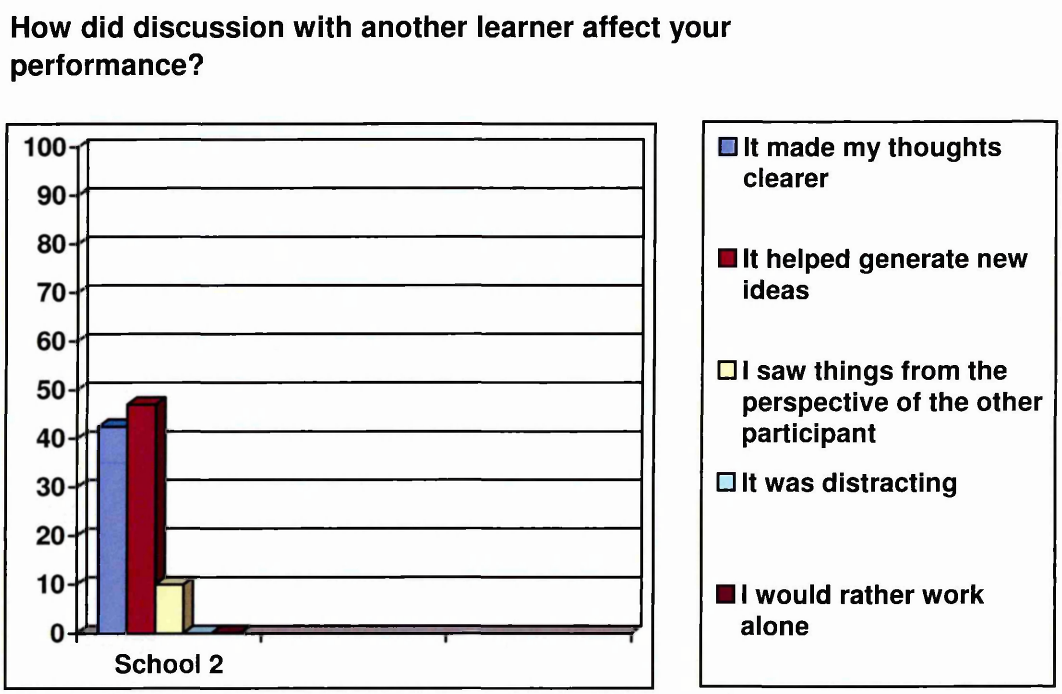


Figure 27 The potential of collaboration to enhance creativity

As we can see from figure 27, *'It helped generate new ideas'* was the most popular choice for an answer, throughout all four sessions. School 1 provided no coherent answer on the question.

8.3.3. Collaboration, not competition and the issue of ownership

It is interesting to observe that probably the most important part of the discussion, which developed in the 'Archimedes screw idea' dialogue - a new idea of how to refine the existing design solution, was proposed not by the student who had the original idea but from the other collaborating learner. This provided a significant indication of how the two learners felt about ownership of the idea. The two learners freely exchanged their experiences and made contributions without the constraints of thinking about ownership. They were observed to work in complete collaboration with each other, without competition, their driving force being pure exploration and excitement about discovery, in an attempt to improve the initial idea. This suggested that learners were intrinsically motivated and whilst discussing this idea, saw it as a collaborative effort. In this way we have the perfect conditions for true original thinking. More will be said on the issue of competition later in the chapter, but at the stage of working on the sketching task learners seemed to be selflessly motivated by the desire to arrive at an original solution.

Jones and Issroff (2005) speak positively of the issue of ownership as an affective factor in human computer interactions. They see ownership as a product of students feeling in control of their learning – or making learning their own. *'Ownership of the learning problem'* is seen as a highly motivating factor (Jones, Issroff, 2005: 405). This is also supported by Laurillard who maintains the importance of the learners discovering individual meaning in the learning, and being able to carry knowledge into the context of their own work (Laurillard, 2002(d)). This highly positive outlook on ownership as a motivating factor makes sense in some respects, however – the observation of the pair in the Archimedes screw idea dialogue and in the Cutting board idea dialogue which is discussed in section 8.3.4, indicate strongly that there is a necessary stage of temporarily forgetting the notion of ownership of an idea to the advantage of collective effort. As we have observed in these dialogues, it was the variety of ideas and the interaction of these different ideas and perspectives, which made it possible for learners to arrive at a truly original solution. For the period of time of being engaged with and fully immersed in such collaborative effort and discussion, learners temporarily forgot whom the idea had originally belonged to. This made possible a certain ease and spontaneity to the discussion, which generated original solutions.

Therefore ownership, even though it can be seen as a motivating factor in some circumstances, can in fact also be interpreted as an extrinsically motivating factor in other instances – where it becomes associated with individualism, promoting personal achievement above the value of the collective effort. In the evaluation sessions it was precisely when students reached a stage of putting the idea of ownership aside that they managed to gain the spirit of free exploration and creativity.

The idea of a form of collective ownership, rather than an individual one emerges as more supportive of creativity. It was not that learners renounced ownership and felt dissociated from the idea, but rather seemed to forget their individual ownership of it and engaged with the ideas as a purely collective effort.

This leads to the conclusion that the truly exploratory, unhindered and original flights of imagination in learners need a stage of renouncing the idea of individual ownership in favour of a collective form of ownership for the sake of creative exploration.

Further conditions, which contribute to this productive learning situation are, firstly, the set-up containing a learner-to-learner model of dialogue. This allows learners to speak freely and let their thought develop in any direction they would naturally choose, further enhanced by an atmosphere of humour and spontaneity.

Secondly, an important part of the learner-to-learner model is the role of the ecoWarrior learning environment. The system provided the necessary content and the necessary stimulus for learners to engage with the issue at hand. A key factor was the powerful influence of multimedia in conditioning the learner's mindset to adapt to a generative thinking mode. Within ecoWarrior several features come into play to make this possible.

One stage of the ecoWarrior learning environment asks learners to interact with existing products in the context of eco design. In another - the Two Players game - they are brought some way towards developing their own thinking concerned with issues of sustainability. The conflict becomes personally relevant precisely because learners are exploring an image of their own work. The stage of the Explore sequences gets learners to engage in a series of narrative and interactive tasks where their goal is to establish ways of responding to the issue of, for example, compostability through a design solution. Learners choose a Sketching Task to complete, which brings them to the stage of executing their solution.

Each of these stages in turn contributes to creating a situation where the learner is stimulated in thinking about their own work in the context of sustainability and is ready to respond with generative thought. These stages can be described as providing a structure for the learning interactions. The need for such a structure within computer-based learning corresponds to the need for a curriculum within a learning setting (Boyle, 1997(b)). However, the key difference between the way a traditional curriculum works and the way computer based learning is structured, is that the nature of multimedia structural elements allows them to be used in a non-linear way. As was observed in the evaluation of ecoWarrior learners chose their own paths of interactions through the learning content. Moreover, when learners did display such patterns of interactions – being able to choose the learning content they viewed according to their personal interests – this indicated the level of independent thought and autonomous learning of that student. The less linear and the more tailored to their own learning needs their path of interaction was, the more autonomous the learner and the more original the thinking process and outcome were likely to be. The evaluation of ecoWarrior makes it apparent that the potential of a computer based learning environment to be used in a non-linear way and its flexibility in being customised to the specific learner's needs is unique and is the essence of its advantage over traditional curriculum forms.

To summarise - the key conditions for a productive and creative dialogue, to occur between two learners are:

- A moderated role of the teacher as an authority figure;
- Dialogue, which is primarily occurring between (or among) learners;
- A variety of media combined in order to allow learners to actively engage in exploring content, give them a problem solving structure and stimulate their imaginations.
- A multimedia learning environment, which provides a pedagogical structure to the learning interactions, and which allows for learners to engage with content in a non linear way, customising their learning paths to suit their specific learning needs.

8.3.4. The importance of face-to-face communication

The following dialogue, which will be referred to as the 'Cutting board idea', had similar outcomes to the ‘Archimedes screw idea’ dialogue discussed in section 8.3.3 in a sense that it follows a similar pattern in its distribution of cumulative, exploratory and disputational talk. A new phenomenon was observed in this dialogue. While the idea started off as a discussion between two learners, a third learner joined in, bringing a much desired balance and versatility to the discussion.

Alongside this, several important observations emerged within the discourse, which allowed the researcher to define more specifically the role of the teacher within a non-authoritarian learning environment. Specific instances were identified where it was felt that the teacher’s intervention was necessary for thought to develop and be reinforced. The stages where teacher intervention could have the most positive effects have been identified.

<table>
<tr><td colspan="4">Cutting board idea
School 2, Session 3 – Exploring renewable materials
Participants: C, T and J - learners, learner J joins in the dialogue at a later stage
Supporting video material:
Appendix 5, CuttingBoardIdea.mpeg</td></tr>
<tr><td>T:</td><td>What they do is they take a sliver out</td><td></td><td>Cumulative – makes his</td></tr>
</table>

	the side...And then you can press them down and make them flat - and you have a chunk of wood there. And it can replace timber or laminates or whatever.		thinking known to the other learner and the teacher.
Teacher:	*That's nice - I like that. So what is your second task then (starts reading outloud the second task).*		Cumulative and exploratory- Teacher gives positive reinforcement; encourages learners to proceed with sketching task
C:	*So what do we have to do?*		Exploratory: Student becomes interested in the idea
T:	*Use the design that you have and try and replace any woods you have with bamboo laminates.*		Cumulative – the learner explains the idea of the task to the other learner - trying to establish common understanding
C:	*We can have an armchair - made out of bent laminate.*		Exploratory - tries to form a task / a shared goal by open suggestion
T:	*Or chopping board. You can have a chopping board.*		Exploratory - tries to form a task / a shared goal by open suggestion
C:	*A chopping board just made out of bamboo.*		Cumulative – reinforces the idea of the other learner.

T:	*We are not talking bamboo poles again!*	Disputational – refers to previous conversation, tries to steer the direction of thought.
C:	*I know!*	
T:	*That's my chopping board design - it's got the holes on here. So that the juices or whatever would slide down.*	Cumulative - makes his idea explicit to the other learner so that they can establish a common goal
J:	*What was your idea?*	Exploratory – this is the third learner intervening – he tries to take part in the shared goal of learners C and T.
C:	*Well it was a cutting board - but it went up like that in the middle.*	Cumulative - provides information describing the idea. Through repetition the learner is also further reinforcing his idea.
J:	*Why?!*	Argumentative - 'why?'
C:	*So you can put in - whatever you want to put in - tomatoes - in there.*	Cumulative – explains and defends the idea; also exploratory – since the learner gradually adds more detail to his explanation.

J:	*Why do you need to cut tomatoes and put three spikes in your tomato?*		Disputational - opposes the idea of the spikes, but also exploratory - tries to understand the reasoning
C:	*Well - see - you slice your tomato - and all the juice and stuff that comes out of it ...*		Exploratory – makes his thinking explicit, giving arguments for how it would work.
J:	*No but - how do you slice it - you have to push it down so you know that it's got through and then...*		Exploratory – points to possible flaws in the idea, but supports his point of view with reasonable arguments.
C:	*No, no, no - then you'd use a knife...*		Exploratory – defends his idea and gives arguments for his thinking.
J:	*That just holds it still while obviously the tomato is so weak it obviously punctures so it goes woof!*		Disputational - points to a flaw in the idea, but also exploratory, since his argument is reasonable.
T:	*But you don't... the idea with the tomato is that...*		Exploratory – tries to defend his idea, and argumentative as well.
C:	*And all the juices and stuff run down the gutters into the bottom where they are collected.*		Exploratory - adds detail to the idea, which has been prompted by the ongoing discussion

J:	*What juices - it's not like - a pie - tomato pie!* *(they laugh)* *You might actually have to put that on the product because most people probably wouldn't think it was a pie. Go on let me see it again...He's all there like - trying to maintain his pride - "This is good! This is good!" and then he hides it all away (laughs)*		Humorous, exploratory – the humorous outlook the learner takes on the idea actually helps add detail and consider it from different points of view.
T:	*It's essentially a juicer...*		Exploratory - posits a possible new interpretation on what the product is about
C:	*No! It doesn't juice!*		Disputational – rejects the idea
T:	*But it catches juice! Hence it's essentially a juicer.*		Exploratory - gives arguments to support his statement
J:	*But what if you've got big bits of meat?*		Exploratory - offers possible interpretations of the issue.
T:	*Well we were designing a chopping board...*		Exploratory - offers solutions to the issue posed; and cumulative – recaps what has been done so far in order to progress to new thinking.

J:	*Yeah?*		Cumulative
T:	*This is around the chopping board.*		Exploratory - offers a different way of thinking to the issue posed
J:	*You don't cut a big piece of meat like that.*		Disputational - refutes the suggestion
T:	*All the pieces would fall off into the tray amongst the juices.*		Exploratory - describes a function which responds to the issue
C:	*Then you get your tomato soup or whatever. You stick it in the fridge and use it on a skewer or whatever. Anyway - the thing is - what do you cut onto a cutting board - top ten items.*		Cumulative and exploratory - reinforces the idea adding more detail to it. Also slightly humorous.
J:	*Erm - chicken breast. I'd put chicken breast up at the front.*		Cumulative and exploratory - contributes to the idea in this way supporting it
C:	*You don't cut meat!*		Disputational
J:	*I cut chicken breast before I cook it.*		Exploratory - gives arguments for his suggestion
T:	*Meat - meat is probably the main thing you would use a chopping board for.*		Exploratory and cumulative - supports J's idea

J:	*(looks at the list) Is that a cherry tomato or a normal tomato - I need some idea of scale.*		Exploratory - tries to get more idea of the detail involved in the design
C:	*Normal.*		Cumulative
T:	*Normal tomato.*		Cumulative
J:	*So it's about this big... and your chicken breast is about this big... so your chicken breast is going to be about there.*		Exploratory - active thinking - tries to visualise the shape by drawing
Teacher:	You all alright?		Cumulative - tries to get an idea of their progress
J:	*Yes we were just discussing how ... To be honest it looks a bit cramped like that.*		Exploratory - comments on the spatial qualities of the design
C:	*What if you made it less - dome shaped and more gentle-sloped. Not with big spikes but sort of little -*		Exploratory - offers a solution, builds on the idea of the previous speaker
J:	*Little stud things - yes.*		Cumulative and exploratory - asserts the idea and builds on it.
T:	*This is coming along.*		Cumulative - positive reinforcement
C:	*Then you can start to sort of...*		Cumulative.

T:	*Yes so from above here you would have ... let's say your tomato is that size on it.*		Exploratory and cumulative - tries to add detail to the idea and reinforces it in this way
J:	*Wouldn't you have the studs sort of all the way - so like completely covering it for a bigger thing. So the studs are completely covering it so the studs sort of go in the same sort of channel - so you'd have a stud then a drain then a stud then a drain, so there's lines moving down.*		Exploratory - adds to the idea by actively thinking about improvements of the cutting board's functions.
C:	*Is there a trapping - so that dome shape has got little metal or wooden studs that sort of hold the wood in place so it wouldn't move.*		Exploratory - poses an issue and contributes to the idea
Researcher asks the learners to explain their idea:			
C:	*It's a chopping board - that's sort of dome shaped and it has little metal or wooden studs - to sort of hold the food in place.*		Speaks with confidence in his voice - his confidence comes from the fact that this was a collaboratively constructed idea.
T:	*The idea behind it is really that you'd use a bamboo laminate for it -*		Cumulative - through

	because bamboo is quite strong and it would be able to stand the chopping. And at the same time bamboo is good for the environment as well. So that's the idea that we went with and it is turning into a chopping board idea.		explaining the idea to me he is both reinforcing the previous student's utterance and he is taking the opportunity to validate the idea by presenting it to someone external to the group within which the idea was conceived.
Researcher:	*Can you actually shape laminate this way?*		Exploratory
T:	*I mean you can get wooden things that are shaped a similar way so I assume you would be able to shape it - whether it is by sanding or just cutting it in the factory.*		Cumulative - explains his thinking supporting it with logical reasoning
Researcher:	*How do the metal parts - do they just slot in or...*		Exploratory - trying to get a fuller picture of the idea and to establish whether students have thought about it in sufficient depth
T:	*Well they would probably be done in the factory pressed in by some machine. They would be little metal studs I think...that would be pressed into the laminate. So it would be able to grip the things you are cutting.*		Cumulative - explains his thinking supporting it with logical reasoning

In this sequence the discussion started off with two learners, C and T, conversing. Halfway through their discussion a third learner, J, joined in. While this intervention by a third learner proved to be crucial to the positive development of ideas by the learners, it was purely incidental and occurred merely because this third learner was sitting in proximity to the working pair and overheard their discussion. This is something, which would naturally happen within a classroom on a regular basis and is by no means out of the ordinary. This instance is similar to what Cook discusses as the value of 'a listening approach to the use of dialogue' (Cook, 2002 : 6), where learning is a result of overhearing conversations. He terms this phenomenon *'productive overhearing'* and relates it to Lave and Wenger's trajectories of learning in legitimate peripheral participation. Spitulnik et. al. term this the *'knowledge building motivation'* for designing learning environments to afford collaboration, where an opportunity is provided for collective understanding to be developed by bringing together different perspectives (Spitulnik, Bouillion, Rummel, Clark & Fischer, 2003 : 21). A similar conclusion was arrived at in the Learning Needs interviews, where D&T learners themselves spoke about the relationship between discussing ideas as a group and creativity (Ehiyazaryan, Williams and Lewis, 2004).

It is significant to note, that such productive overhearing happens most naturally in face-to-face communications. While the IMLE did not predefine interaction between three learners to occur, it has displayed the capacity to encourage a fluidity of discussion and interactions amongst students, not unlike this, which D&T students would normally have in a studio or workshop situation. The claim can be made therefore that the system supports the authentic activities of the subject setting (Lave, Wenger, 1991(d): 89) and blends into the natural learning environment. This reinforces the need to preserve the face-to-face model of communication specifically at the stage of initial idea generation. Instances will be discussed however where later on in the thinking process an external opinion is necessary which would make online communication a desirable feature.

The intervention of the third learner had a positive effect on the learning interactions. The two learners who initially conceived the idea were beginning to fall into a disputational mode of conversation, arguing about details in the idea. When the third learner came into the interactions, the discourse, which developed became more focused on specific issues and it actually led them to a conclusion about the idea. This is not to say that the dispute was single-handedly resolved. The argumentative discussion became even more intense and lively with the intervention of the third learner. However, ultimately it resulted in a desired outcome - learners detailing the idea and in their own words, *'getting somewhere'* with it. This proved important in terms of autonomy. By the time the researcher intervened asking learners to explain their idea, they had already formed a coherent story about the idea, which they could relate, defend and feel confident about.

The issue with lack of autonomy is that it is common for a learner to be uncertain about the value of an idea at the very start of conceiving it. It would have been easy for an authority figure such as a teacher therefore to dissuade learners that their idea was worth something at this point. However, because learners had discussed the idea to some depth and given each other feedback and reinforcement multiple times within their dialogue, they had a substantial degree of confidence in subsequently describing their idea to the researcher. Through collaborative discussion learners had acquired the confidence to present and defend the idea and were assured of its value. From the video clip illustrating this discussion (see Appendix 5, CuttingBoardIdea.mpeg), we can see that there was a change in the learners' tone of voice when explaining their idea to the researcher - learners were confident in explaining their idea, and went into the fine details of its description. Thus the claim can be made that the feedback, which learners gave to each other played a crucial role in their development as autonomous learners, and allowed learners to engage in creative risk taking, such as they may have been inhibited to adopt as an attitude if left to work on their own.

A further aspect, which the 'Cutting board idea' dialogue brought to attention, was the way the conversational mode changed in the presence and in the absence of a teacher or learning facilitator. In the absence of an authority figure, the conversation among the three learners had a quality of unrestrained spontaneity, where humorous remarks were exchanged. Such remarks enriched the discussion and made learners think about the fine detailing of the idea. As described in research literature (Vass, 2002; Isssroff, del Soldato

1996; Stables, 2004) the elements of humour intermixed in the discussion, made the conversation more light-hearted and allowed for divergent thought to thrive.

However, far from obsolete, the importance of teacher intervention became evident at a later stage of the discussion. Having achieved an agreement on most of the parameters of the idea, learners reached a stage where they felt the need to communicate it to someone external to the idea generation process. This was evident since learners started to fall into the cumulative mode of discussion – reinforcing their idea, and covering all angles once again, in a similar way to the one observed in the 'Archimedes screw' idea. This is where teacher intervention was necessary, as a way of providing external feedback and reinforcement to learners' thoughts.

Therefore while a teacher's say is necessary for the idea to acquire validity outside the small circle in which it was generated, it is still desirable to keep teacher intervention to a minimum in the very early stages of idea generation.

Another identifiable point where teacher intervention is necessary is at the very beginning of the idea generation process. Once again looking at the 'Cutting board idea', the pair of students had already been discussing the Renewable materials in the Explore sequence at some length but had not yet engaged in the sketching task. The teacher intervened asking them to look at the sketching task and casually asking their opinion on it - this acted to encourage learners to engage with the exercise (see Appendix 5,Teacher intervention2.mpeg; Teacher intervention3.mpeg). Since the Sketching task is perceived as work by learners they may avoid completing it, and may hover in an undirected discussion without engaging hands on with the exercise. The learners obviously needed a slight degree of extrinsic motivation, which would encourage them to engage.

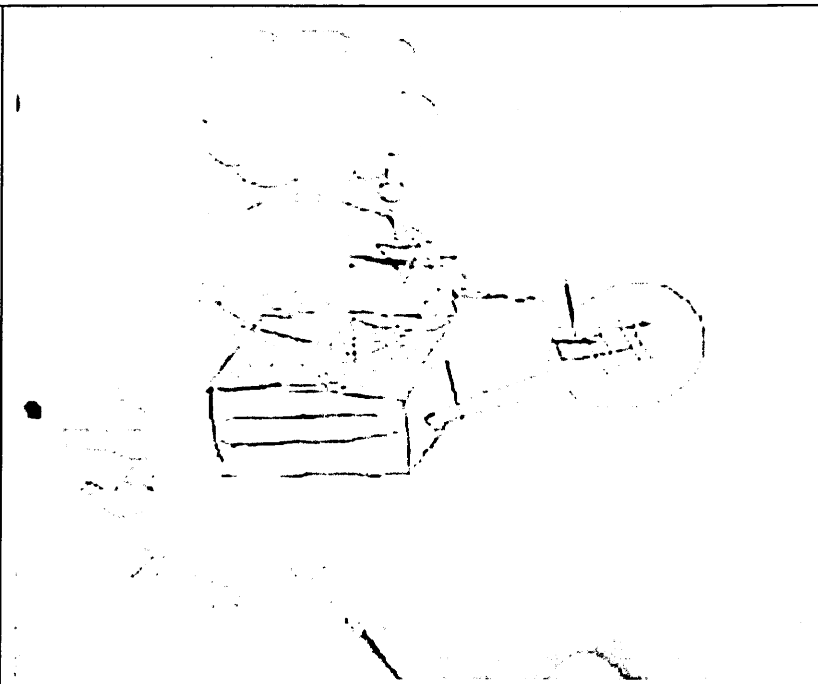
So the role of the teacher is identified as crucial at two key stages in the generative thought process:

- In encouraging learners to engage with the task, or problem solving activity;

- In providing feedback and external validity to students' already conceived ideas. It is important to note that such feedback needs to come only after learners have had a chance to discuss the idea amongst themselves, in order to preserve their autonomy.

8.3.5. Making an expert out of the learner

Several instances in the data collected pointed to the value of making the learner feel they are the expert in a situation. Such an approach not only affords learners an opportunity to express themselves and share their ideas with peers and teacher, but also to gain self-esteem and become confident in the value of their ideas. In the following example, the learner was asked to explain his idea for a composting system to the rest of the class.

School 2, Session 1 **The apple tree idea** **Participants: Learners J, T, Researcher**	
Researcher:	*Can we all listen to J. while he explains his idea.*
J:	*We have an apple tree with a compost heap around it. So you put your compost in the apple tree - in a compost bin around the apple tree and then all the nutrients from the compost help the apple tree grow. And as the apple tree grows it produces nice rosy apples which then fall when they are ripe which in turn pushes a balance which*

	pushes a pump which blows air into the compost heap which makes it decompose a lot faster. And then all the apples roll down into a slurry pit and that's where the pigs come in, and so it goes round and round and round, so you can use the manure from the pigs to feed the compost heap.
Researcher:	*How much time do you think it takes for this system to start going?*
J:	*Well it takes a while to get it going - to get all the apples growing but after a while it works itself.*
T:	*Where's the benefit?*
J:	*Where's the benefit? It is for a garden grower to grow pigs and apples and make compost.*
	The rest of the students ask a few more questions. They then use ecoWarrior to explore learner J's idea.

In this instance the idea discussed was complex and its meaning was not necessarily evident from the sketch (see above). Verbally expressing the idea allowed the learner an opportunity to elucidate and reinforce it in his mind. It also afforded opportunities for other learners to bring in their own perspectives and ask questions.

The hypothesis develops that verbal expression and sharing ideas with the external world is a way of reinforcing the idea and gaining self-esteem in its validity. Such verbal expression therefore contributes to the development of creative and autonomous behaviour in learners.

Following is a supporting instance of the value of making the learner an expert:

School 2, Session 2

The class was asked to play the Two Players game with the Archimedes screw idea for a compost bin of learners T. and C. The camera is observing one pair of learners. They are assigning materials to learners T. and C.'s compost bin idea. They are looking at the materials specification menu, and are wondering what to put in, since they do not know enough about the product to continue.

J: *C., what are you making your archimedes screw out of?*
C: *Plastic.*
J: *What kind of plastic?*

In this instance one learner's idea was chosen as interesting and the learner was asked to explain how it worked to the rest of the students. The whole group had to subsequently play the Two Players game with this student's idea. This acted as a trigger for conversations, where the class were referring to the two learners who had the idea asking them to explain how it worked, what it was made of in order to be able to engage more meaningfully with the game. The advantage of this approach was that if anything was unclear about the idea the class could always refer to the person who generated the idea This approach was observed to accomplish two things:

1) It triggered exploratory talk between learners. In order to complete the Two Players game – selecting materials, assigning values - learners needed to know what materials and manufacturing processes were used in the product, the number of materials etc. At the same time their only source of information were the two learners who generated the idea. This necessitated exploratory talk to develop within the class, where the two learners had to gradually explain their idea to their peers in detail.

2) It gave responsibility to the person whose idea was being discussed. For the period of time in which their idea was being discussed, learners C. and T. were the experts, they held the specialist knowledge, which everyone needed. I would make the argument that this acts to reinforce the learner's autonomy and promotes their self-esteem, which as we know from research literature - is a central condition for creativity to develop in the learner.

The value of verbally expressing ideas was identified in Chapter 5 - the analysis of the Learning Needs interviews. It further answers the key question posed in Chapter 6:

- How can an interactive media learning environment provide the necessary conditions for the affective factors of learning characteristic of creativity – such as self-esteem, autonomy, intrinsic motivation - to develop in the learner?

Making an expert out of the learner is one way of satisfying the affective factors of learning associated with creativity. Where the learner is placed in the role of expert, their autonomy and self-esteem are affected positively.
It is necessary to note that placing the learner in an expert role was a process driven by the teacher in the learning situation. In these terms the teacher is an essential entity in the learning interactions, and takes an active part in building up the learner's autonomy and self-esteem.

8.3.6. Timing - when to introduce the learning environment

One of the difficulties, which were encountered in the use of the learning environment, was the timing in which it was delivered. In School 2 the timing proved favourable – at the end of their AS level, year 12, learners were actively looking for contexts to explore within their project work in the following year, therefore ecoWarrior performed an evident function. In contrast, in School 1 learners were in the process of completing a project and the use of ecoWarrior seemed as additional work. Learners often failed to see the relevance of the content of ecoWarrior to their ongoing work. Therefore while the ideas of sustainable product design may have been interesting and even applicable, there was no realistic opportunity within such a short project to apply them.

A further factor, which needs to be considered where the timing of delivery of the learning environment is concerned, is the degree of intervention, which the teacher feels they need to exercise. Midway through a project and when nearing the end of a project, teachers are likely to adopt a more guiding role, aiming to aid learners in the completion of a successful project. As we can see from the following two examples of dialogues between teacher and learner, the possibility for divergent thinking and creative ideas is much more confined, when the teacher has started to adopt the role of guidance figure.

<table>
<tr><td colspan="2">School 1, Session 3

Participants:
Teacher
Learner N
Learner A</td></tr>
<tr><td>Teacher:</td><td>(to N) You cannot make the frame. You have only got the time to make the thing that clamps on to a frame. That's why you need that section, that tubular section of steel for you to decide how you are going to make some component that attaches to the frame, how you are going to make it adaptable, movable, it might be a universal joint that you move around, it might be – you know we talked about friction, so you can position it and then it stays in position depending on what angle it used to be. It swivels. Yes? That's what we are doing. So that it attaches to the frame. Frame, you have already designed. Alright?
(N. is nodding. Looking at his sheet and thinking)</td></tr>
<tr><td>Teacher:</td><td>(To learner A) Is yours definitely solar powered?</td></tr>
<tr><td></td><td></td></tr>
</table>

A:	*I don't know.*
Teacher:	*There are no 'I don't know'-s anymore. We've got two weeks left to make it. Two weeks – to make – this is a final product. I hope you are not going anywhere this Easter. This should be your final design. This should be your drawing you are giving to me and that should have been last term. With all your dimensions, your plan for manufacture, and you should be requesting materials and making right now.*

These examples illustrate learners making safe choices because they are far advanced with their project timing and are prepared to accept all the suggestions, which the teacher provides. Any divergent ideas, which the ecoWarrior learning environment provides at this stage, would therefore not be welcome - it is too late for students to research new technology for example.

Following is an example, in which the student has expressed an interest in solar power as an alternative means of energy. However we can observe the precise stage at which his enthusiasm is cut short, primarily by the restrictions on time for completing his ongoing project work:

Participants: **Researcher** **Learner L**	
Observation:	*L spends a long time on the solar headphones, he is obviously drawn to this product and likes it so wants to learn more about it. Then returns to the game and lapses in inactivity, turns to see where I am and if he needs to be doing anything else.*

Researcher:	*Did it give you any ideas?*
L:	*Yes but I don't think it can really work with my project. Because it is too expensive to use solar power. It's a very good idea to use it but – I don't know - I don't have the time to use it so...*
Researcher:	*Ok.*

While the learner had the willingness to use the idea of solar power in his work, the suggestion for a deeper exploration into sustainable energy sources made him reconsider. Using solar power would have meant that the student would have to do more research into the technology, and as the teacher explained at the beginning of the lesson - they did no have much time. Inappropriate timing therefore was what cut short the implementation of the student's original ideas into actual project work. Once again - because it is designed to inspire ideas, which are different, more adventurous and more deeply considered, the ecoWarrior learning environment needs to be delivered to learners early enough for them to be able to research their ideas thoroughly and to acquire the necessary confidence in exploring more challenging contexts.

8.3.7. Guidelines

Guideline - Defining the role of the teacher in supporting learner autonomy

When defining the role of the teacher in learning interactions, which include a multimedia learning environment, the teacher's as well as the learner's motivation needs to be taken into account. As was said earlier the advantage of using an IMLE is in encouraging creative dialogues to take place, where new ideas are generated and refined. The difference between the teacher-to-learner and learner-to-learner dialogues, which developed while students were using the learning environment, emerges from the external motivating factors which influence teachers' behaviour. In addressing a learner, a teacher is partly extrinsically motivated, by the necessity to bring learners to a stage of a successful completion of their project work. In this way a teacher inevitably looks on a student's project from a more pragmatic point of view. While such an attitude is necessary for a project to be successful it is not always beneficial to creativity and generating ideas.

In this respect dialogues, which develop between two or more learners have an advantage. Within the ecoWarrior evaluative sessions students have displayed a capacity for intrinsic motivation towards generating design ideas. Instances were observed where the goal of two learners conversing is to come up with improvements on a design problem, rather than to consider the outcome in terms of grades. This research does not suggest that students are always entirely intrinsically motivated. However they have the advantage of being involved in the creative process and experiencing the 'flow' state which Chikszentmihalyi describes, which makes it more likely that they could become intrinsically motivated.

Teacher intervention in the idea generation and development in a setting where a learning environment is also present, becomes necessary and productive only after learners have generated the idea and have discussed it amongst themselves, thus giving each other some confidence in the validity of the idea, before introducing it to the teacher. A multimedia learning environment is able to provide the necessary content, stimulus and an activity based environment for the learner for them to start the idea generation process. A multimedia learning environment also structures learners' interactions in a way which gradually leads them to a stage where they are ready to generate such ideas. As a result the necessity for the teacher to provide a brief for the learners, to place their learning in context is delegated to the learning environment. The role of the teacher therefore becomes much more supportive rather than guiding at this stage, allowing learners to take centre stage in guiding their own learning, thus becoming more autonomous.

The stage at which it is necessary for the teacher to actively intervene once again is when learners have already generated the idea and have had a collaborative discussion on it amongst themselves. This time for discussion away from the teacher allows learners to consider the idea from different angles, and through argument acquire a certain degree of confidence in its value. There is a marked difference in the conversation between learner and teacher regarding the learner's idea, after the learner has had a collaborative discussion with other learners. The learner starts to display a higher degree of confidence in discussion with the teacher, and is able to offer constructive arguments, which support their idea. The learner has become an independent thinker, much more prone to developing original thought outside of the shadow of authority.

Guideline - Defining the role of the learning environment in supporting learner autonomy

As was observed in both The Archimedes screw idea (see section 8.3.2) and The Cutting Board Idea dialogues (section 8.3.4), the role of the learning environment was one of a support system, a trigger for thought, and a structure for the development of original thought and creative, collaborative enquiry. From this point of view the learning environment faces several important requirements, which need to be satisfied in order for it to be able to afford the necessary level of learning:

1. In order to support learning in D&T the learning environment needs to support the authentic activities of the subject of D&T. The learning environment needs to function within the D&T classroom, and be integrated into it. This would mean that students' interactions with the computer would not be seen or used as separate from the rest of the learning activities or interactions which naturally occur between learners, or between learners and teacher. The computer's role is to facilitate such interactions and trigger them, as well as to provide content around which they should evolve. The dialogue which occurred between learners in the 'Archimedes Screw idea' and culminated in them arriving at an interesting idea for a compost bin provides a prime example of both the importance of such dialogues and the value of the learning environment

as providing the necessary conditions for such learning to occur. Further - the dialogue of the 'Cutting board idea' which started as an interaction between two learners and a computer and evolved as a discussion among three learners, led to the development of an interesting idea. This makes it necessary to consider that the learning environment needs to be flexible enough and blend in with the learning setting sufficiently to allow for such flexibility of the interactions and for such spontaneous dialogue to emerge.

2. A computer based learning environment provides a structure for the learning interactions, which due to the nature of interactive media is non-linear and discovery based. This is an alternative to the traditional curriculum, which is based on the principles of instructional design. In these terms ecoWarrior's non-linear, discovery orientated platform for learning provides a unique opportunity for learners to choose their paths of interaction with the learning material. This type of approach enhances autonomy in the learner by leading them into considering what they themselves are interested in and how they would like for their learning experience to be tailored. In these terms the approach to learning is user-centred with the individual's learning needs at the heart of the learning experience. The value of the discovery approach to independent learning and learner autonomy became evident in the ecoWarrior evaluative sessions where learners who chose their own paths of interaction, rather than allowing themselves to be led through a sequence in a linear way. It was usually these learners who engaged in productive dialogues which resulted in original thinking.

Guideline - The significance of learner-to-learner dialogue

The role of learner-to-learner dialogue which develops within the use of the learning environment, is crucial to the development of original thought. Evidence from the evaluative sessions supports this - virtually all of the ideas which led to an interesting design solution were developed as a collaborative effort between two or more learners, and it was the discussion which they had which served to propel their thought forward and turn it into an interesting solution, with the necessary amount of detail. In these terms the condition, which the learning environment needs to comply with is to provide a social constructivist learning platform where learner-to-learner interactions are facilitated. The following benefits emerging from a learner-to-learner dialogic interaction were observed:

- Undoubtedly the diversity of the ideas generated and design solutions arrived at was greater when more than one learner participated in the idea generation process. The different perspectives brought into play were immediately visible and contributed with adding detail and refining the idea in both the 'Archimedes screw idea' and the 'Cutting board idea'. Within these interactions learners naturally adopted different roles - one of them questioning the idea and the other responding by changing the concept or defending the solution. This resulted in a perfect collaborative, rather than competitive setting for the discussion, which in turn led to exploratory dialogue.

- Learners consistently referred to the ideas they developed as a joint effort; in addition they did not claim ownership of the ideas at any point. This behaviour could be seen as intrinsically motivated and driven by the experience of discovery and exploration. Collaboration and exploratory talk form the best conditions for original thought to develop. The evidence presented of collaboration amongst learners establishes learner-to-learner dialogue as an essential condition for creativity in any type of learning environment.

- A positive change was observed in students' confidence and autonomy. This occurred in instances where learners had been able to generate and discuss ideas amongst themselves without the intervention of an authority figure. The recommendation, which can be made, is to ensure that learners have had the chance to generate as well as critically discuss their ideas amongst themselves. Only after such discussion between learners would teacher intervention be fruitful, without compromising learner autonomy.

- Within the evaluative sessions of ecoWarrior humorous and spontaneous talk emerged naturally in students' dialogues with each other, alongside exploratory talk. This makes it necessary to consider humour as an element, which encourages learners to free expression and independent thought. Humour and spontaneity are by-products of the dialogue, which develops amongst learners, which highlights one more reason why learner-to-learner collaboration is valuable and necessary.

The role of learner-to-learner dialogue can therefore be summarised as necessary to provide the following conditions:

- Diversity of ideas is greater – this encourages original thought;
- The role of one learner is to question and the role of the other is to respond - equality of the relationship is preserved;
- Humour and spontaneity;
- Learners give confidence to one another;
- The emphasis should fall on collective as opposed to personal ownership of ideas which have emerged in collaboration.

Guideline - Treating the learner as expert

A good strategy for reinforcing learner autonomy is to place the learner in a position of expert, where the rest of the class are referring to this learner for specialist knowledge. The way ecoWarrior implements this is to allow for learners to generate ideas in the 'Explore' sequences, then import these ideas into the system as sketches. These sketches then become part of the system, and it is possible for a whole class of learners to interact with them. Because the nature of the interaction demands that learners should know about the product they are analysing – what materials it uses, what manufacturing processes, what energy sources – the class are in a position where they have to find out about the product by engaging in exploratory talk with the person who generated the idea. Such exploratory talk manages to make all learners involved in considering the product in more depth, as well as having the effect of boosting the confidence, self-esteem and, ultimately, the autonomy of the learner who generated the idea.

Guideline - When to introduce a multimedia learning environment which aims to affect learners' creativity

Learning material, which aims to inspire creativity and generative thinking in the learner, needs to be delivered early in the timescale of a project. This is necessary in order to allow learners to explore freely and be almost entirely intrinsically motivated and unrestrained in their ideas. In order for learners to be able to bring in the elements of humour and spontaneity to their work, they need to be free from the constraints of deadlines and marking – which are considered to be extrinsically motivating factors. To relate this to the D&T A level curriculum, material such as ecoWarrior provides, aiming to enhance autonomy and creativity, needs to be delivered at the end of Y12, at a stage where learners are exploring contexts to work within for their final year 13 self directed project.

Appropriate timing also has implications for the degree of teacher involvement, which would be necessary. When delivered at this stage there will be no need for the teacher to be heavily involved with any decision-making processes. This would allow the learner to determine the direction which the project is going to take. In this way learners would be allowed to gradually move towards increasing participation and towards taking full control of their work.

Chapter 9. Analysis part 2 – Factors Influencing Attitude Change

9.1. Introduction

As discussed in Chapter 6, a learning environment which aims to broaden students' perceptions, stimulate their curiosity, and encourage them to be innovative, needs to work on the affective layer of learning. The statements describing a change in the affective layer of learning within the ecoWarrior learning environment (see section 6.3.6, Target objective 3) have been used as examples of initial areas of focus for observation.

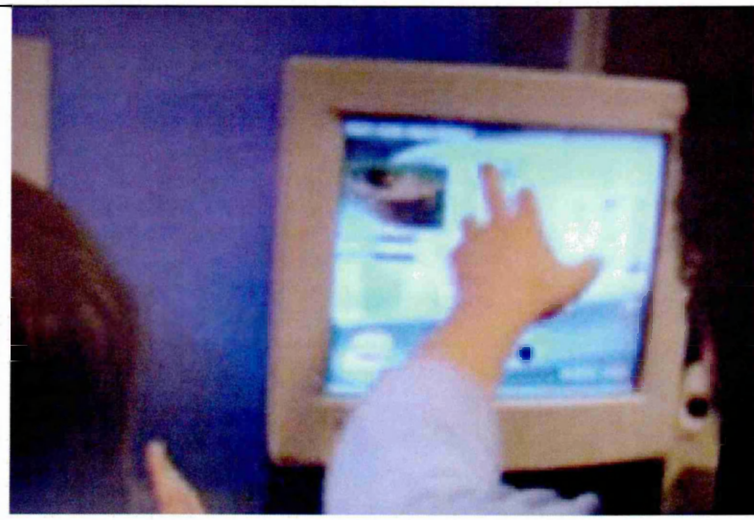
This section explores how affective factors influence attitude change in the learner and whether they manage to provide positive conditions for the development of original thought.

9.2. Personalising the interactions, emotional response and change in attitude

This section of the evaluation of ecoWarrior discusses personalising the learning interactions and emotional response as factors, which condition a change in the learner's attitude. As in Gagne's treatment of attitude change, learning interactions, for which emotional involvement on the side of the learner is characteristic, are more likely to lead to meaning making and ultimately to creativity (Gagne, 1985(a)).

9.2.1. Emotional response and change in attitude

One indication of the pedagogical responsiveness of the learning environment was the effect it had on learners on an emotional level. Students frequently showed disappointment at their choices being wrong and 'losing a life' as a result as well as enjoyment of winning the game and gaining points. Such responses served as an indication that the direct manipulation style of interaction worked on the learners' affective layer – students were engaged with the interaction and learning content on an emotional level, which is in itself the basis for a change in the learner's attitude, and prepares the ground for creativity. The following are two supporting examples of the emotional response, which the game elicited from students:

School 2, Session 1 **Participants:** **Learner J** **Learner B** **(supporting video material available: Appendix 5, Interface.mpg)**	
	There are disappointed exclamations where the learners have 'lost a life'.
B:	*Is it non toxic? It's non toxic.*
B:	*Mono materials – 'those that consist of pure materials' – so that's gonna be… yes! Right we've got two more.*
J:	*What is that one? Lightweight –*
T:	*Strength to weight ratio.*
They drag it and score a point.	

B:	*Oh yes!*
B. and J. win their game.	

This excerpt shows a high level of motivation and emotional response from the learners. The User Experience questionnaire (Appendix 7) provides further data for the ecoWarrior learning environment's capacity for being a stimulating and enjoyable experience. Data from the questionnaire suggests the two schools have conflicting views. As is evident from figure 25, in school 2 learners had a generally positive experience, with 54% marking it as *'a lot of fun'* and the rest as *'any other learning material'*. No negative answers were given to this question in school 2. In contrast the experience of learners in School 1 was different with only 15 % marking this as an enjoyable experience and an average of 40% marking it as confusing.

It is necessary to acknowledge that in this respect the learning experience depends to a great extent on the interactive qualities of the learning environment performing with the adequate speed. As the computers in School 1 were slow, learners were sometimes frustrated with the system.

However the positive instance in School 2, where technology performed to the necessary standard indicates unequivocally that the learning experience was stimulating and enjoyable. Following is a supporting instance, which also focuses on the positive stimulating experience of a learner engaging with the interactive content:

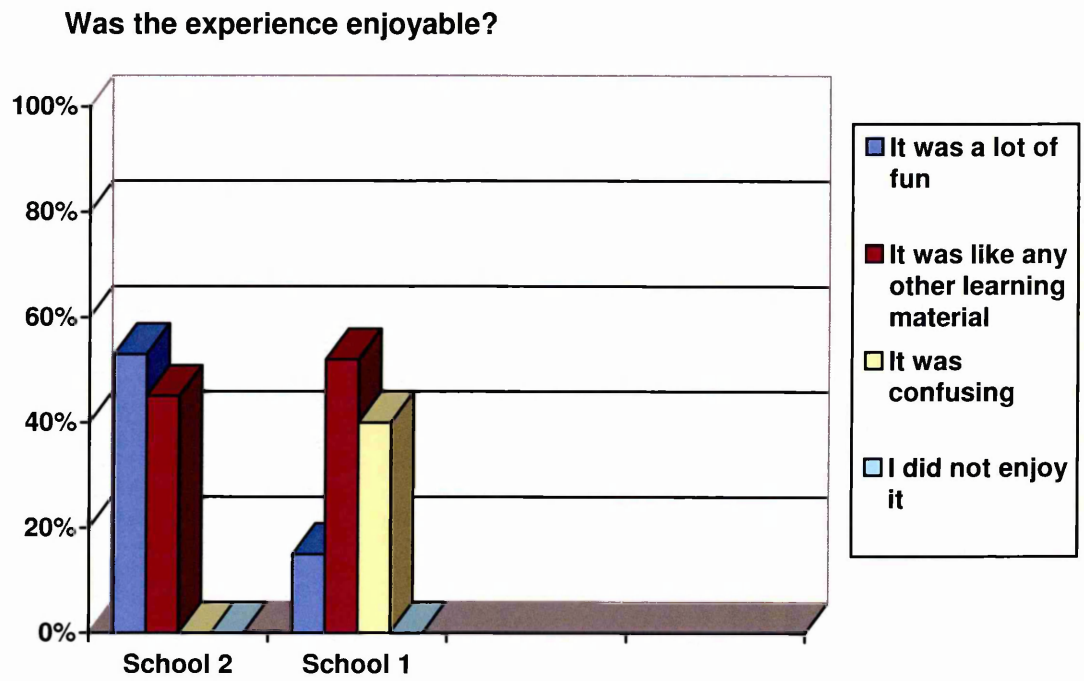


Figure 28 Level of stimulus when engaging with the learning environment

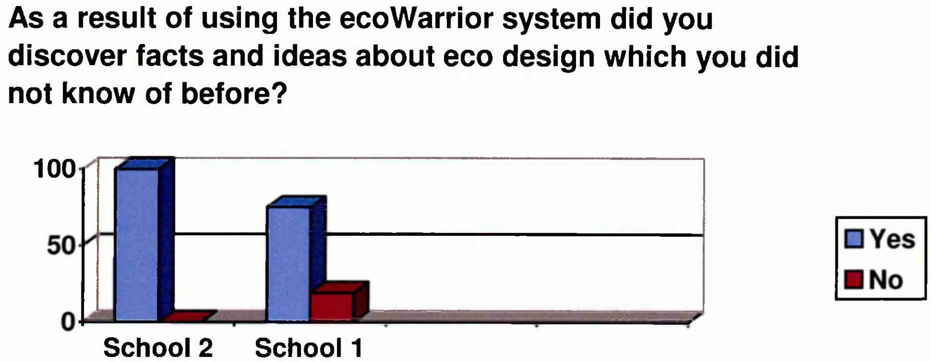
School 2, Session 1 **Participants:** **Learner B** **Learner J** **Teacher** **(supporting video material available: see Appendix 5, GrassChair.mpg)**	
	Camera moves to learner B. - he is looking at the products page

B:	*That is crazy! So it's just like - biodegradable - it must biodegrade. Then moves to the chair made of rushes –*
B:	*That's a pretty... chair – love that. Takes up quite a bit of room though. Yeah - why not just chop these off. Goes back to the grass chair –*
B:	*I want one of these - I want a grass chair.*
Teacher:	*We can make that.*
B	*turns to his teacher:*
B:	*Out of grass?!?*
J:	*Have you got a high-pressure extruder?*
B:	*Look they are made out of grass. (points to the screen)*
Teacher:	*Excellent.*
B:	*How good is that.*

Teacher:	*I saw a really good one it was made out of...*
B:	*And then when you don't want it - just chuck it in your garden.*
Teacher:	*...made out of cardboard and then you put it and fold it and then the cardboard can degrade.*
B:	*That's crazy!*

This instance is significant in showing the beginning of attitude change developing in the learner. The learner is confronted with a design solution which he has not imagined possible, and which as a result stimulates his imagination. We can see this from the enthusiasm in his voice, as well as from his verbal expressions: *'I love that'; 'That's crazy!'.* The learner's perceptions have been challenged by the unusual design solution, which is what creates the change in the student's affective layer of learning. The fact that he also experiences pleasure in the design is evidence of stimulus. Here we recognise a key condition identified as necessary for the learner's creative development – stimulus and its resulting affective response.

The user experience questionnaire provides further supporting evidence for the potential of the learning content of ecoWarrior to provide stimulating content, which learners find challenging and new (fig. 29).



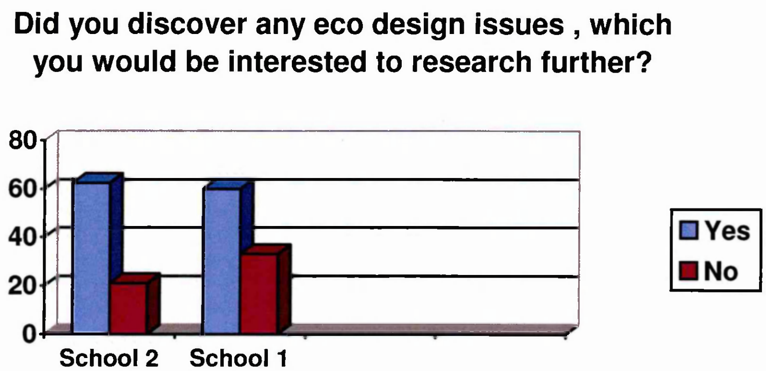


Figure 29 Evidence of the extent to which students found ecoWarrior to be challenging

100 % of participants in school 2 and 75% in school 1 found the content was new to them. However novelty is not a sufficient criterion for judging stimulus. The second question ascertains whether the content was engaging enough for learners to take the experience away with them and apply it within their project work, addressing the research question posed in Chapter 6:

- Do students show signs that they are carrying knowledge acquired within the artificial learning situation of the game into their own project work?

62 % of participants in School 2 and 60 % of participants in School 1 indicated that they would be interested in exploring this content further.

These figures indicate learners' motivation and the stimulus, which the learning experience managed to elicit. Only content which is engaging and stimulating could hold learners' attention and stand out in their memory as a possibility for future project work.

The role of the learning environment in developing this initial affective response into a learning experience is in providing the content necessary for the learner to reflect on the experience. For example in the grass chair example (see Appendix 5, GrassChair.mpg), the manufacturing technique used in the grass chair was described in ecoWarrior, and the materials used were listed. Further, a sketching activity was provided so the learner could respond actively to the content viewed. The learning environment provided the context in which the initial affective response could develop into a learning experience.

Teacher's role

A further aspect to consider was the role which the teacher played in this interaction (Appendix 5, GrassChair.mpg). The teacher engaged with the content by sharing his own experience of such designs: *'I saw a really good one made out of cardboard the other day'*. He also told the learner that it is possible to make such designs in the workshops, which led to a chain of practical questions *'Have you got a high pressure extruder?'* In this way the teacher provides the relationship with the authentic activities of the subject setting of D&T (Lave, Wenger, 1991(a)) – he makes the relationship between what could be achieved in the workshops and the content on screen. This acted to equip the learner with the capability of designing something, which could realistically be prototyped, and situates his newly acquired knowledge in the context of D&T work.

Guideline - emotional response and change in attitude

The instance of the grass chair identifies several factors necessary for attitude change to develop in the learner.

Firstly, the learning content needs to be engaging and provide the element of surprise, to expose the learner to the unusual, the unexpected, in this way working on the affective layer of learning (Gagne, 1985). Such learning material provides the basis for a qualitative change in attitude in the learner and therefore the starting point of original thought – How is this possible, how was it made? Does it not get wet when it rains? How is the grass held together? – these are all questions, which are generated by looking at an unusual, visually challenging idea. The advantage of a multiple, dynamic medium was that the learner was able to experience the product in several different ways – animation was used to describe the manufacturing technique; a visual showed the end result; a short textual description made explicit the materials used, as well as the making process.

Secondly, the role of the teacher was essential in situating the content within the authentic activities of the subject. The teacher offered suggestions of how this product could be made in the workshops, and suggested that the learner could make one themselves, as well as share their own experiences of similar design ideas.

Thirdly, alongside the dialogue, which took place between teacher and learner a parallel stream of discussion developed amongst the students who were looking at this product at the same time. In this way learners exchanged impressions of the product idea in the spontaneous and informal manner which is natural to their learning interactions. In a sense, what this dialogue provided was peer approval of the idea by all learners, which makes it interesting and a worthy topic of discussion, and from a pedagogical point of view, led to exploratory talk.

The visually exciting content presentation was linked to an activity – a sketching task. This provides a direct path for the learner to be able to respond to the content viewed not by mere reflection but through reflection in action, where their thinking is allowed to take a two dimensional form.

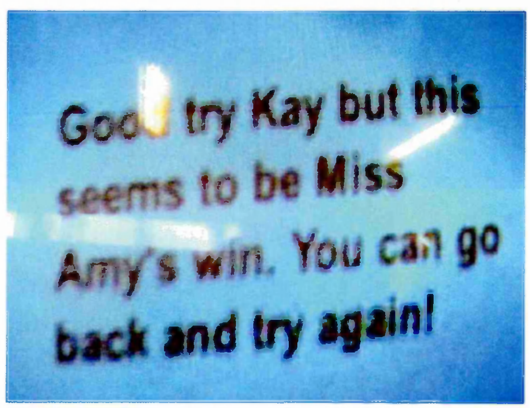
These four elements – engaging, interactive, unusual content; a teacher to situate the learning content in the activities of the D&T subject; spontaneous exploratory talk with other learners, and an activity which offers opportunities for creative response – are the starting point for original, generative thought. When using VLEs all of these elements need to come into play to achieve the desired attitude change.

We have so far discussed the emotional response, which an interactive learning environment can elicit from learners through the engaging presentation of content. However, as the evaluative sessions uncovered, there are further strategies, not relying on content as much as on forms of interacting with the learner and engaging them in dialogue, through which deep interaction and attitude change can be affected. These strategies establish a personalised form of interaction with the learner, which affects the way students perceive the content and the degree to which they engage with this content, in a positive way.

The following sections discuss the Name Entry, Assign values and Materials selection features from the point of view of their capacity for personalising the interactions and their benefits to learning.

9.2.2. Personalising the learning interactions through the Name Entry feature

Several instances were observed, where students entered 'virtual' names or character names in the name entry fields. The following example illustrates this phenomenon:

School 2, Session 1 **Participants:** **Learner J** **Learner B** **(supporting video material available, Appendix 5, TwoPlayers.mpg)**	
J. moves on to assigning values.	

B:	*Corb! Come you can play now.*
Observation:	*J. goes through several fictitious names until he chooses one.*
B:	*(reads off screen) 'Master Chief'.*
	J. changes his mind and deletes the entry.
B:	*What are you doing - just decide on a name!*
	J. writes 'Spartan 111 John'.
B:	*Oh - come on!*
B:	*What shall I call myself?... 'Shenobi'...*

Such behaviour can be attributed partly to the nature of the environment being resolved as an interactive game. Learners started to adopt behaviour customary to playing computer games or participating in online forums, RPGs etc - inventing a personality and adopting a persona to suit the virtual world. Names like 'Shenobi', 'Keiser chief', 'Miss Amy' started to appear in the name entry fields. This is characteristic of the phenomenon of acting in the game - where the learner becomes a persona on screen and starts to identify with the learning environment - this predisposes to a deep level of immersion and interactivity. Of course the naming feature in itself could only go as far as predisposing learners to this kind of immersion, preparing them for interaction with the learning environment. The pedagogical potential of such an experience is important in terms of the level of stimulus and engagement, which is produced in the learner.

Learners are displaying behaviours which are close to what Papert describes as 'acting in', in his Turtle Geometry learning environment (Papert, 1980(a)). By inventing a fictitious, on-screen name, learners become actors in the virtual world, and this prepares them to accept the freedom to engage in exploratory play. This is essential from the point of view of creativity and generative thought.

Further, we can make the relationship between a personalised form of interaction and learners starting to care about the choices they are making and decisions they are taking within the learning environment. All of these collectively contribute to changing the learner's attitude towards their own work.

The name entry element can therefore be seen as a way of alerting the learner that the interactions are personalised, and in this way introducing them to the idea that from this point onwards all meaning making would be personally relevant. In a sense the name entry field is preparing the learner to take active control over their interactions and start thinking of the meaning created as personally relevant.

Guideline - Personalising the learning interactions through the Name Entry feature

Employing the tools of multimedia to personalise the human computer interactions has a positive effect on learning, where a change in the affective layer of learning is desired. Elements such as a name entry field, alert the learner to the fact that the interactions are personalised, and any actions that the learner undertakes within the system would have personal consequences. Such consequences can refer not only to surface learning outcomes such as winning or losing the learning game, but also, and more crucially, to any design ideas learners would have had during the interactions. As a result learners would take these ideas more personally and seriously, making it more likely that they would take this knowledge forward into their project work.

Other than the name entry feature, design elements, which contributed to personalising the interactions, were:

- The Assign Values feature;
- Importing an image of their own work into the learning environment;
- The Materials Selection feature;
- The Sketching tasks within the 'Explore' sequences.

The following sections explore the pedagogical and affective value of each of these features.

9.2.3. Personalising the learning interactions through the Assign Values feature

The evaluation of ecoWarrior identified a difference in the way learners related to the concepts in eco design when using the Assign Values feature, from the way they treated these concepts when using the Case Study module (see Appendix 6 for description). The following examples provide evidence of the level of learner engagement, which the Assign Values feature elicits.

School 2, Session 1

They move on to the 'Assign values' page. B reads the description.

B: *Oh you can't be seeing this J. (to me) He shouldn't be seeing this, should he?*

Researcher: *No.*

B: *(theatrical gesture with his hand) Away!*

J: I can't see.

B: *I forgot what they all mean. (to J) This could take a while J.*

B. puts 'renewable in to the 1 point slot. Leaves out lightweight. B is reading each very carefully before assigning a value.

It is evident that learner B. is displaying a change in his attitude. Previous observations of learner B interacting with the game, show him wanting to get to the interactive sequence as fast as possible. As a result he often omitted reading the story of the product and moved on to the interactive game immediately. In this instance however we can observe a definite change in B's attitude where he stops and spends quite a long time exploring the meanings of the concepts before assigning them as values. This means he is actively reflecting on his choices and the way they relate to his own idea.

This change in attitude can be attributed to the fact that his exploration now uses his own work as a starting point, which means that all exploration, interactions and meaning making from this point onwards become personally relevant. As Mercer identifies - meaning making and learning happen when the enquiry originates from the learner's own cognitive conflict (Mercer, 2000 (b): 135). Considering that the subject of D&T involves a creative element where students design and make their own design solution, it is natural that D&T learners would take their work as something very personal, even relating to them as individuals. Therefore using students' design work is a good way to make learning personally relevant, and as a result prepare the ground for learning.

9.2.4. Personalising the learning interactions through the Materials Selection feature

The Materials selection feature (see Appendix 6) had positive effects on learning both in contributing to personalising the learning interactions with the computer and in encouraging reflective thought. The following examples provide evidence of this:

Researcher:	*Ok - can we all stop for a minute and, L., could you tell us what the idea is?*
L:	*It's an alarm - to stop children from going into rooms where they shouldn't go like - into the kitchen where there's dangerous knives.*

Researcher:	*Right. And how does it work?*
L:	*It's - when the door's open there's like a circuit or like - a laser sensitive thing that when it's broke the alarm goes off and alerts the parents.*
Researcher:	*Ok. What is it made of?*
L:	*High impact polystyrene...Not polyst... ehm - HIPS. Thermosetting HIPS I think. I'm not...I'm not sure yet.*
Researcher:	*So it's completely made of plastics? The whole casing is plastic?*
L:	*Yes.*
	Learner L. is searching for the material in the Materials Selection menu.
Researcher:	*Does it have any other parts?*
L:	*No I don't think so.*
Researcher:	*How is it put together - does it snap together or?*

L:	*Oh yes. Got to have screws for the wall. So what material are screws?*
Researcher:	*Stainless steel I'd say.*
	Learner L selects stainless steel.

In this dialogue the learner is describing to the researcher his idea for a safety alarm. Talking about their idea is a good way for learners themselves to put their thoughts in order and consider aspects of the design, which they had not considered previously. It appears that the Materials Selection feature offers significant learning potential. Students are encouraged to actively consider what materials they are using. As we can see from the dialogue above, one of the results of this was that learner L discovered his product was using more materials than he expected. He was also reminded that he should be aware of the type of plastic he was using for the shell of the product. Later on when considering improvements for the product, these features, the additional material used for fastenings and the type of plastic used as well as the form of the product, became the foundation for his idea for improving the design idea.

The issues of the degree of complexity of the materials specification menu and the amount of information it provides become clear. The following is an example of the need to support subject knowledge acquisition:

	L. and N. are using the computer together and specifying materials for N's tool storage unit.
Researcher:	*Can you tell me why you are choosing plastics?*
N:	*Because of the main frame - there would be friction so it*

	should stay...(inaudible) He chooses 'high tensile steel'.
Researcher:	*And why are you choosing high tensile steel?*
N:	*Because the main frame has got to be quite strong.*

From this dialogue it is apparent that the materials specification menu involves learners in complex decision-making about issues, which they may not have already considered at this stage of designing. This type of reflection leads to meaning making, and therefore needs to be supported by subject knowledge. Guidance is needed on the properties and uses for each material in the materials selection menu.

Very often students asked questions concerning a specific type of plastic for example. This inquisitiveness and readiness to learn indicates that they were interested in finding out more and this point in the interaction would be the perfect place to provide further knowledge, as the content students are manipulating has already been made personally relevant. For this reason it is likely that the and content offered to them would be willingly absorbed and would find its place in the learner's cognitive processing easily and effortlessly - learning at this stage has become situated in the authentic activities of the subject setting and we need to make good use of it.

The same behaviour was exhibited by all learners in both schools when using the Materials selection feature - students were careful and generally cared about the materials they were inputting (see Appendix 6, MaterialsSelection.mpg). This opportunity for acquiring knowledge in a reflective way seems a perfect place for tutors or systems to provide key learning.

The care which students take at this stage in selecting the materials is indicative that they have started to care about the content which they are creating, or in other words - they have started taking knowledge and meaning made within the system as personally relevant. This is a positive indicator of change in the learners' attitude towards their own work.

The pedagogic value of menu systems is not generally recognised in the literature. Lansdale for example gives the following description of menu systems:

'Menu systems are most valuable when the users do not need to know, or cannot be expected to know beforehand, what the valid range of inputs to the dialogue are.'

(Lansdale, Ormerod, 1995: 40)

However, observation of learners using the Materials Selection menu suggests it aided reflection. The materials selection feature performed the following key features:

- a revision tool;
- an opportunity for discussion.

By repeatedly using the feature in order to define their design idea, learners had to traverse the menus numerous times, and reconsider each time the materials they were using, as well as take into account materials they had not thought of using. In this way the Materials Selection feature can be seen as a reflective tool.

Further, the materials selection menu was a starting point for dialogue, which got students discussing what would be appropriate to use. In this way it was a successful collaborative tool.

Finally, the discussions, which developed between the researcher in the role of teacher and the learners, managed to reveal a lot about the misconceptions, which learners had regarding materials use and properties. This makes the materials selection feature a valuable evaluative tool for teachers.

Guideline:

Menu systems have several functions which contribute to supporting the development of learner autonomy. Firstly, menu systems require making choices, which can provide a point for discussion for learners. In this way collaborative work is supported. Secondly, repeatedly traversing menus aids recall. Through the repetitive nature of their use, menus can make a good revision feature. In the ecoWarrior IMLE, learners used menu systems to choose materials for their design idea. By using menu systems they repeatedly traversed the information making relationships such as for example, classifying stainless steel as a non-ferrous metal. Finally, menu systems can be used as an evaluative and monitoring tool, both for teachers and for self-assessment. The choices which the learner makes can be recorded by the system and further used as an indication of how well the learner knows the material studied.

9.3. Narrative and emotional response

In addition to personalising the learning interactions, interactive media has the advantage of engaging learners through narrative story telling. As discussed in the literature review, narrative can elicit emotional response, making it a powerful tool for learning (see section 2.1.2, The potential of narrative as motivation). The following examples illustrate learners' emotional response and consequent meaning making elicited by narrative:

Observation: *The two girls read the 'Sustainability or whatever' intro carefully. This is obvious from the amount of time they are spending on it, their body language which shows them being immersed in the environment and finally the manner in which they scroll through the text - the text has two paragraphs, the window it is contained in only displays one paragraph at a time. They concentrated on reading the first part, then scrolled down to the second, after a long enough pause to have been able to read through the first. There was no random scrolling up and down.*

As a narrative tool the 'Sustainability or whatever' intro worked quite successfully. Learners spent a long time reading its content carefully. This shows an interest in the subject matter and a willingness to engage with the learning material. Within this narrative, the call and response technique for eliciting emotional response from the reader was applied (Mercer, 2000 (a): 73). The D&T learner was addressed personally, placing an emphasis on the fact that as a designer they are personally responsible for the future of the planet. The role of the designer in promoting sustainable design was discussed, making the reader the subject of discussion and allowing them to see themselves in this role. This technique creates the feeling of one-to-one dialogue with the author and is more likely to work on the affective layer of learning, as Mercer describes (Mercer, 2000 (a)).

The following is an instance of a pair of learners, who, as a result of engaging with a narrative element in the 'Durable' explore sequence, managed to arrive at an understanding of the meaning of the concept of anti-fashion:

School 2, Session 4 **Participants:** **Learner K** **Learner C** **Teacher** **(supporting video material available:** **see Appendix 5, AntiFashionDialogue.mpg)**	
C:	*Terracotta.*
Teacher:	*Ceramic.*
K:	*That's it ceramic! And then they fire it or glaze it.*
C:	*But they break pretty easily. Or they chip out all the time. ...inaudible...*
	They discuss the concept of anti-fashion and decide to do the sketching task. A. draws the outline of a mug.

While there is nothing original in the mug, which the learner draws, a mug is in fact a perfect example of an anti-fashion design since its basic shape has not changed in decades. The material used in a mug - ceramics - is durable. This makes it a good example of anti-fashion design. The girls' sketch shows that even though they did not come up with an original idea they actually understood the concepts introduced in the multimedia of durability and anti-fashion. It was at the point of K. saying *' they are never going to change'* that their realisation and shared understanding of what anti-fashion means started to develop.

What inspired the girls' discussion and shaped their understanding was once again the narrative form of delivering the story of what anti-fashion design means. Within ecoWarrior, bringing together the reflective form of engagement with narrative and the form of active exploration was achieved by an appropriate structuring of events. The story element explaining the concept of 'anti-fashion' was supported by a sketching task asking the learners to respond to the new concept with an original idea. This format of narrative followed by a task was consistently applied across the learning environment – a narrative element, which creates the reflective mode, immediately followed by a task, requiring creative action on the side of the learner. Such sequencing of events managed to combine generative with reflective thought, identified as the key to unlocking original thought in the learner (NACCCE, 1999).

Further evidence of the educational potential of narrative is discussed in Chapter 10, where narrative is seen as supporting both collaborative and individual learning.

Guideline - Narrative as a form of attitude change

Narrative has great potential for meaning making and reflection in the learner. When used in an educational context there are significant benefits to be had from successfully combining the two, seemingly opposing, narrative and interactive forms of delivery. In the subject of D&T specifically where reflection in action is required, using narrative would encourage a reflective attitude to work, while using tasks would bring in the element of action.

The strongest point of narrative in terms of attitude change is that it has the advantage of creating an emotional response in the learner, which in itself is the basis for attitude change and in turn prepares the ground for creativity.

9.4. Distribution of control and emotional response

The relationship between the learners' use of navigation and autonomy has already been discussed in Chapter 8. It was established that the choice of more self-directed forms of navigation such as preference for non-linear navigation, driven by the learner's interests, indicates increased levels of learner control and autonomy. This section links the learner's confidence and ability with knowledge in the subject domain with their ability to handle self-directed learning. This is a significant connection to explore, since the attitude of the learner towards self-directed work has a direct influence on their attitude to the learning experience in general. Getting the balance right in terms of the degree of learner control afforded is crucial to ensuring positive emotional response and attitude change, such as are necessary factors for nurturing creativity in the learner.

9.4.1. Adverse effects on the learner's capacity for self-directed learning

Bekier argues that the learner's domain knowledge and degree of motivation have a direct influence on how well they respond to a learner-controlled environment.

'Hannafin (1984) notes that increasing learner control over navigation / interaction leads to more effective learning when the learner has prior domain knowledge and experience. The more prior knowledge, the more learner control can be exercised. An inverse relationship also exists.'

(Bekier, 2005)

Bekier also quotes Williams on the relationship between subject knowledge and learner controlled environments:

'In particular, both student prior knowledge and ability were found to predict student success under learner control...[as well as the] student's level of motivation. Students with little or no prior domain knowledge and students who had "low ability" or were unmotivated, tended to perform poorly under learner control.'

(Williams in Bekier, 2005)

Within the evaluation of the ecoWarrior learning environment, which is primarily a learner controlled environment, this relationship became apparent. A particular learner was observed who started off in their interactions and the whole concept of the learning game with a sceptical outlook, performed poorly and often expressed feelings of not seeing the point of the exercise. This learner failed to utilise the knowledge implicit in the learning environment and relate it to their own project work. The learning experience never managed to become personally relevant with this learner and they struggled to progress in any way. The following observation illustrates this point:

Session 1, School 1 **Participants:** **Learner S** **Researcher**	***Transcript***	***Conversation analysis***
Observation:	*S drags the icons without reading the meanings of any of them. He first drags the ones which he has seen while learner A was assigning them then drags some random ones and loses the game within seconds. It is as if he is boycotting the exercise.*	
Researcher (To S)	*Shall we try it with your idea.*	
S:	*You can if you want.*	The learner is refusing to

		take part in the decision making process and dissociates himself completely from the events in the learning setting, delegating all actions to the learning facilitator: *'You can if you want'.* This is equal to refusing to take control, or undertake any actions, which will result in the making learning personally relevant.
	S imports his idea without hesitation. He seems confident with the interface. He gets to materials specification.	This indicates that the learner has no issues with understanding or being able to confidently use the interface – the reasons for his lack of engagement are not to do with control of the interface but with refusing to take control of the learning content.
Researcher:	*Can you explain what it is?*	An attempt to involve the learner in a discussion.
S:	*It's a cash box, to be used with tills where the cash is kept.*	
Researcher:	*OK so what is different*	An attempt to involve the

	about it?	learner in a discussion.
S:	*I don't know really I'm just doing a quick design. I haven't really thought about it. I haven't finished my research yet.*	Unwillingness to engage in a discussion. This shows low level of engagement with his own work, which is a sign of low subject knowledge and experience in D&T.
Researcher:	*Which part is made of oak?*	
S:	*The handle.*	One word answer. Indicates an unwillingness to engage in exploratory discussion.
Researcher:	*Is the body steel?*	
S:	*M-h*	One word answer. Indicates an unwillingness to engage in exploratory discussion.
Researcher:	*And which parts are acrylic?*	
S:	*The tray inside it.*	One word answer. Indicates an unwillingness to engage in exploratory

		discussion.
	He gets to assigning values to the concepts. He drags them without reading the meanings. He drags 'reclaimed, I intervene:	
Researcher:	*Which part do you think this relates to?*	Exploratory question, trying to understand the learner's logic in the choices he makes.
S:	*I haven't got a clue, I'm just dragging. What is that?*	Indicates low level of motivation. The learner has not engaged enough to understand the interface beyond the physical actions it allows him to perform. He has not engaged with the contextual level of the interaction.
Researcher:	*If you click on it, it will show you a description.*	
	He starts reading the meanings of concepts. He ends up missing to drag the most important and the most key	The learner feigns an attempt to understand the context of the exercise, after external pressure is placed on him to do so

	concepts, which apply to his design - 'durable' and 'abundant'. He has dragged 'mono materials', 'reclaimed', 'renewable, 'recycled', 'non toxic'. Most of these are correct apart from 'reclaimed, because admittedly he dragged this concept randomly. It appears from the way he was dragging without reading the meanings that he was dragging randomly throughout.	(see researcher's comment above). It is difficult to say whether the learner has by some chance memorised the concepts' meanings or whether he blindly dragged them, however, the fact that he does not engage with the meanings still remains.

This particular student's lack of engagement with the learning material resulted in inability to benefit from the self-directed nature of the interaction. His negative attitude was displayed first of all in the way the learner spoke of his own work: *'I don't know really I'm just doing a quick design. I haven't really thought about it'.* This utterance, alongside the student's previous description of what the 'design brief' involved: '*It's a cash box, to be used with tills where the cash is kept'*, indicated strongly that issues existed in this learner's engagement with the subject knowledge in general. There was nothing in the student's description to suggest that this was a design idea – it lacked an element of engagement with a design problem, which is essential to all design work. The learner did not make any mention of why and in what way this cash box would make a difference and why it was necessary to redesign it.

It is necessary to acknowledge therefore, that a learning environment, which is primarily learner controlled would not benefit an unmotivated learner, or a learner who has little subject knowledge. As far as a remedial action is concerned, this leads research to acknowledge the necessity to include some form of differentiation to the learning activity. Within such differentiation, alongside an ostensibly learner led and independent learning model, other ways of delivery more reliant on instruction and a step by step linear process of content delivery need to be implemented, specifically targeting those learners who are unaccustomed to independent learning and are uncomfortable with taking control.

As a result, differentiating learning emerges as one of the issues for future development of the learning environment. In these terms differentiation is seen as the possibility for a positive intervention through the design or delivery methods of the learning environment. In the following section further issues related to differentiation are discussed.

9.4.2. The nature of the task and learner control

Dillon and Maguire identify differentiation by task as one of the key approaches to catering to individual learners' needs (Dillon; Maguire, 2001).

As was discussed earlier in this chapter, the nature of the task is a key element, which has an impact on the affective factors of learning. Jones and Issroff point to some of the difficulties which the nature of the task can pose:

'Some tasks can easily be sub-divided and distributed between different individuals. However, individuals lose ownership of parts of the task and may become uninterested. This is a particular problem during computer-based tasks, which occur over a long time. For example, Issroff... discusses a long-term collaboration in which the students could not all work on the task at the same time. There was a breakdown in the collaboration and this had both affective and cognitive consequences for the learner.'

(Jones; Issroff, 2005 : 400)

While the authors identify the issue however, they do not offer advice to the multimedia developer or the pedagogue, regarding how this issue can be addressed. Several instances in the evaluative sessions of ecoWarrior provide evidence for the existence of this phenomenon described by Jones and Issroff. Instances in the data will be described with the aim of eliciting suggestions of how the learning environment can be utilised or improved – either in its design or in its delivery - in order to deal with the issue of lack of engagement in learners due to difficulties in relating to the task.

School 2, Session 4 **Participants:** **Learner J** **Researcher** **(supporting video material available:** **see Appendix 5, OutdoorSeatingIdea.mpg)**	
Observation:	*Learner J ends up working on the idea by himself because learner C is not contributing meaningfully to the discussion. J explains the idea to me:*
J:	*It's like an outdoor chair - it's stone so it's curved across the top so you don't get any water hanging around the top so it's like a curvature at the top. So this area would be more curved to stop water staying on the chair. So it's drying up faster.*

In this instance one of the learners carried out the sketching task as an individual activity because the other learner in the pair was unwilling to contribute. The idea which emerged was good and responded to the sketching task. However it lacked that element of detailing which is apparent in ideas which had been discussed amongst two or more learners – such as the

Archimedes screw idea and the Cutting board idea (see Chapter 8, sections 8.3.3 and 8.3.4). Those ideas tended to have a depth of thought and detail such as an idea conceived and developed by only one individual lacks.

Figure 30 Students sketching

Apart from confirming the importance of the collaborative aspect of learning, this is also evidence that the sketching task is not a form of learning activity all students could easily relate to. In School 1 there was one individual who did not manage to relate to the sketching task, and in the School 2 group there were two students who never produced a sketch. However, this does not mean they did not respond to the sketching task at all. These learners contributed with verbal comments and discussion and actively reflected on the content, while at the same time refusing to draw.

Guideline - Differentiation by task

The provision of different activities to individuals is recommended. Tasks need to be matched to students' abilities, aptitudes and interests. Issues to consider in differentiating activities to individual learners' needs are:

- the choice of stimulus activity;
- the depth of detail provided;
- clues given;
- ways in which links with previous learning are highlighted;
- (most importantly) the outcomes which are stressed.

(Dillon, 2001 : 165)

If students are given a choice in the task they choose then this will allow them to develop their specific aptitudes ad interests.

Dillon and Maguire point out that there is a danger with differentiating activities on the basis of learners' ability:
'Mapping predetermined routes for different ability groups' - for example - average, above average, below average - can have negative consequences. Such an approach may reinforce the teacher's initial expectations of the student and not allow for the possibility that the student may have progressed in their learning. Further, the damaging effect which such 'labelling' would have on the student needs to be considered, since it may lead them to believe that they belong to a certain ability group which they cannot transgress.

It is recommended that any differentiation by task should therefore be done on the basis of the type of task rather than placing an emphasis on the level of ability.

In terms of how differentiation can be built into learning content, two possibilities have been identified, on the basis of students' responses to the ecoWarrior learning content.

Firstly, a computer based learning environment has a marked advantage as a medium for delivering such differentiation in a subtle way, which would deal elegantly with the danger of labelling a learner as belonging to a specific ability group. An IMLE can provide differentiation by merely providing different pathways through content. In this way for those learners less confident in their knowledge, and less inclined towards learner control, the interaction could follow a linear structure, of introduction, an information based part, an activity based part and a summary section. The same learning content, by being viewed differently, can be customised to the needs of the more confident, independent learner.

Secondly, the issue exists of reluctance to use 2D sketching on the side of some students. This issue has also been identified by Welch (Welch, et. al. :

2003). The authors make the point that sketching is not used by novice learner as a way of designing, mainly due to the high level of skill required to communicate through drawing. Instead what tends to happen is that learners proceed immediately to 3D modelling.

The authors' findings point to two facts:

'sketching is not a method by which pupils explore solutions...discussion between pupils plays a major role in the clarification of ideas'

(Welch, et. al., 2003)

In this way the authors identify dialogue and collaborative discussion as an alternative to sketching in their function of exploring design solutions.

One way of incorporating this within ecoWarrior would be to provide differentiation by task. This can be done by giving a choice of activity to the learner, either producing a 2D sketch as a response to the task or developing their concept through using a dialogical tool. This could be a tool, which facilitates brainstorming or concept mapping.

This approach would require an exploration of the range of skills and approaches learners bring into the learning setting. The data from the evaluation of ecoWarrior showed that some learners preferred the dialogic tool – 2 Players game - as a way of exploring their ideas, and responded to this more actively than they did to the 'Explore' sequences. This suggests the need for making provisions for dialogic input of any ideas they may have during the 'Explore' sequences. The idea of having a concept mapping tool or a brainstorming tool mentioned above therefore becomes relevant.

Similarly, some of the learners, specifically those who showed an interest in and responded positively to the sketching tasks, were not always as active in the dialogic element of the interaction. This suggests that for these learners it would be necessary to change the sequence of events within the learning environment. Such learners who related to the sketching task and the exploratory sequences more readily than they did with the dialogic interactions, may prefer to start with the explore sequences and then proceed to the dialogic interaction, where - now being more prepared with background context - they would be able to perform better.

A recommendation to the navigation functions of the ecoWarrior learning environment is therefore that the system should be able to start from both the Explore module and the Two Players Game module, thus allowing flexibility in the level of learner control afforded.

Chapter 10. Analysis Part 3 - Supporting Learning through Dialogue - Making Learning Personally Relevant

10.1. Introduction

This chapter looks at specific strategies for making learning personally relevant to the learner through the use of dialogue. Since learning theory is a key focus of this research, different approaches to learning theory are explored from the point of view of how they contribute to the development of learning. The chapter further looks at the way specific elements of instruction support learning.

Since research is considering aspects of computer enabled collaborative work, Laurillard's Conversational Framework was used as a model for evaluation (Laurillard, 2002 (a)). Evaluation focused on identifying the key factors in using the Conversational Framework, which play a role in supporting two different types of knowledge – declarative knowledge and creative thought.

10.2. Dialogue and internal thought for supporting the development of learning – implications for choosing an approach to learning theory

Throughout the evaluative sessions, learners were observed to apply individual and collaborative approaches to learning. This section looks at how both of these approaches to learning coexisted and contributed to learning.

In section 9.2.1 we saw how the example of the Grass Chair excited learners because of its unusual idea, stimulating content and dynamic representation on screen. Alongside the dialogue with teacher and peers a different form of thought developed. The learner experienced a dual type of thought - one was reflective, serving the cognitive function of internalising learning and the other – trying to express and verbalise, to share his feeling with the world, which served a socio-cultural function. This is evident from the broken speech of the learner (see Appendix 5, GrassChair.mpg):

B: *That is crazy! So it's just like - biodegradable - it must biodegrade... Look they are made out of grass. (points to the screen)*
Teacher: *Excellent.*

B: *How good is that.*

Teacher: *I saw a really good one it was made out of...*

B: *And then when you don't want it - just chuck it in your garden.*

Teacher: *...made out of cardboard and then you put it and fold it and then the cardboard can degrade.*

B: *That's crazy!*

Most of the utterances which learner B makes in this excerpt are not direct responses to what the teacher is saying but are extrapolations of the learner's thoughts. It is also evident from the learner's body language that these thoughts are accompanied by emotional intensity. As research literature indicates, such emotional intensity is capable of predisposing the learner towards attitude change. Loveless for example identifies *'enjoyment of experimentation...originality'* as a few of the affective factors which predispose towards creative development (2002 : 8). Both of these factors are present in the Grass Chair example.

On the other hand, the role of the dialogue taking place with teacher and peers is also concerned with expressing a personal preference, and providing an emotional response. The learner wants to let the rest of the participants in the learning setting know that he likes the grass chair:

'I want one of these - I want a grass chair.'

The learner's remarks to the teacher and peers seem to be characterised by a high level of emotional intensity.

The following instance points to another example, which illustrates how internal thought and dialogue work together in meaning making and in conveying an emotional response:

School 2, Session 2

Observation: *Camera moves to learners B and T. The learning pair are looking at the 'Solar Thread' sequence. They open the web link and read the article on solar thread.*

T: *That would be good wouldn't it? The sun could provide the energy for the product.*

The function of the verbal expression in this case was not information provision, since the two learners were exposed to the same content. It was instead, as in the previous example, a form of self-expression on the side of the learner. It is obvious from the nature of the interaction that the learner first individually absorbed the content by reading about the solar thread idea and only after individual reflection shared his thoughts with the other learner. In this way an opportunity for further discussion was created. The possibility for interaction of thoughts and the exchange of ideas emerged, similarly to the instances observed in the two analysed examples of the Archimedes screw idea (section 8.3.2) and the Cutting board idea (section 8.3.4). In this way both approaches to learning, the individual and the social, contributed to meaning making and to eliciting an emotional response from the learner. Further examples of these two approaches working together can be found in Appendix 5 (AntiFashionDialogue.mpg; GrassChair.mpg).

This brings us to the question of the approach to learning theory, which is appropriate for a learning environment if its aim is to enhance creativity and work on the affective layer of learning. As was discussed in the literature review, a dichotomy exists between cognitive and socio-cultural constructivism. The first situates learning in the cognitive acts performed in the learner's mind independent of external influences (Papert, 1980(b)) while the second sees all learning as socially constructed (Vygotsky, 1978 (b); Lave and Wenger, 1991(d): 89). In each of the instances illustrated above we see both approaches being applied simultaneously, by the same person at the same time, with each having a particular significance to the learning process.

Within a learning environment both types of approaches to learning, the cognitive and the socio-cultural, are equally relevant and contribute to the development of thought in the learner in different ways. The individual approach is strongly reflective. Yet, in a learning environment where the aim of learning is creativity, a form of self-expression needs to take place alongside reflection. The social constructivist approach provides such opportunities for self-expression. Both approaches need to be combined within the learning environment in order to enhance learning and creativity.

Guideline – approaches to learning

External dialogue was observed to follow individual reflection in most instances within the ecoWarrior evaluative sessions. As is evident from the data, such dialogue served a specific function in learning – that of allowing the learner a form of self-expression, emotional response and the opportunity to share their individual world with a social group. It is through such discussions that the affective layer of learning can be influenced and the opportunity for enhancing creativity in the learner arises.

In its turn, individual thought provided opportunities for reflection, which is essential to meaning making.

It is recommended that both of these approaches to learning, the individual and the socio-cultural, need to be equally supported in learning environment design in order to provide opportunities for enhancing learning and creativity.

The following section discusses how the choice of media and ways of structuring learning content, work to support different approaches to learning - the individual and the socially situated.

10.3. The role of specific forms of instruction in supporting different approaches to learning - collaborative and individual

The aim of this section is to establish how and to what extent dialogue (collaborative learning) and individual reflection are supported within the learning environment through the use of different forms of instruction. The section makes explicit the role which the selection of specific forms of instruction plays in supporting these different approaches to learning and the impact this has on learning. The consequences for the choice of learning theory are explored.

10.3.1. The capacity of the quiz feature to support both collaborative and individual learning

The following example describes two learners engaged in collaborative discussion. The observation recorded, points to the significance of using a particular form of instruction, the quiz, to promoting collaborative discussion:

Observation 1: *Even though what they are saying is inaudible it is apparent that the students are actually collaborating on each of the choices they make. When one of them proposes a solution - an answer they think is right - they give reasoning as to why they think this answer is appropriate, justifying the choice to the other learner.*

Observation 2: *Learners L and N are completing the 'Durable' quiz together. Only one learner has control over the mouse but the other is pointing at answers. They get one wrong and L points to an alternative answer. They choose that one, which is still wrong. Even though L pointed to the wrong answer, L says as a joke:*
L: *I told you it was the other one.*

While the activity of the quiz never predetermined that learners had to give arguments and reasoning for their choices, they found it natural and necessary to do so. As with the observations reported in the previous section, individual meaning making is often followed by collaborative discussion. The purpose of such dialogue appears to be affective - to express an opinion, to state a preference etc. In Observation 1, dialogue naturally occurred between learners even though it was not prescribed by the system. In Observation 2, the verbal expression was actually a humorous remark, the purpose of which was to give positive reinforcement despite of the learning pair's lack of success.

The role of the interactive learning environment was in contributing with the nature of the learning interactions used in the quiz, which made it possible for such dialogue to take place. Learners felt predisposed to converse, to express opinions, to share their thoughts. In this process, they engaged in a number of useful activities including shared decision-making, exchange of thoughts, productive arguments, all of which are characteristic of meaning making and learning. In return, they received external feedback and positive reinforcement from the other leaner, which, as Chapter 8 identified (see 8.3.7 Guideline – the significance of learner-to-learner dialogue), is an important part of the process of autonomy building.

The quiz belongs to the instructional design tradition, as it implements each of the events of instruction defined by Gagne (Gagne, 1988 : 12). However, as the excerpts above illustrate, when placed in an interactive context where dialogue between learners is encouraged, the quiz becomes a successful collaborative feature, characteristic of the social constructivist approach.

It appears that the most appropriate stance to approaches to learning theory is to adopt a combination of approaches, where no pedagogical tradition is precluded. Rather, the potential of the specific form of instruction for producing the necessary conditions needs to be evaluated individually. The ecoWarrior evaluative sessions identify the quiz as a successful feature for promoting collaboration, even though it originates from the behaviourist tradition of instructional design. It was further identified as an element, which encouraged humour and spontaneity in the learner. These are factors, which can influence the affective layer of learning.

Once again this suggests that the approach to learning theory needs to be a carefully considered mixture of the cognitive, socio-cultural and instructional traditions, since each one of these has been identified to contribute to both learning and creativity when used in the appropriate context.

10.3.2. The capacity of narrative to support both collaborative and individual learning

The previous section discussed the value of supporting both individual and collaborative meaning making within the same learning environment. The quiz as an interactive learning element showed itself able to support both. In this section, the capacity of narrative to support both of these approaches to learning is discussed through the evidence of the ecoWarrior evaluative sessions.

Example 1

School 1, Session 3

Observation: *Learner A is looking at the solar lantern and its parts on the Practical Action website. This learner's interactions are focused on and always use as their starting point the narrative provided.*

While in other learners a preference for the interactive elements was observed, learner A preferred narrative. She displayed behaviour in her interactions with the learning content of consistently starting from narrative as the basis for her design ideas. She was also successful in making meaning from the narrative description, which she then turned into a series of design opportunities. It became apparent that for this particular learner the narrative form worked as the starting point for reflection.

This is an instance of a learner who has a different, more individual approach to other learners, yet is equally well supported in her activities, within the same learning environment. While she is exposed to the same content as the rest of the learners, she uses a different path to arrive at meaning making. Within this she prioritises a different set of instructional elements in her exploration.

However this is not to say that the narrative element is necessarily used by learners who prefer an individual, cognitive constructivist approach to meaning making. In fact narrative lends itself to collaboration just as well as it does to individual meaning making. The following example provides evidence of the capacity of narrative to support collaboration in learners:

Example 2

School 2, Session 1

Observation: *The camera moves to observing another pair – A and K. They are looking at the marble table. They are at the interactive sequence and they have opened the story of the product – they are reading it carefully, pointing at the text and at the image on screen. They have dragged 'durable materials' already and scored a point. K. points to 'abundant materials'. They read the description.*

K: *Well it must be abundant – it's made out of stone.*

They drag 'abundant' and score a point. The girls keep the story of the product open constantly and refer to it in the process of interacting with the game, to guide their choices in the game.

This observation shows the positive influence of using narrative as a way of promoting a reflexive attitude in the learner. Learners used the narrative element at key stages in their reflexive process and referred to it continuously throughout the interaction. One of the key conditions of creativity which the literature review identified was that of reflection:

'an attitude of continuous reflection needs to be supported in the learner' (Rutland and Barlex, 2002)

From the evidence provided in both of the examples above it appears that narrative is used by learners in a way which fulfils a key condition for creativity – that of reflection.

However there was one significant difference between the way the two learners in Example 2 used narrative and the way the single learner in Example 1 used it. This was the element of collaboration. In Example 2 the pair of learners referred to the narrative element in order to make meaning of the learning interactions, but they also used it as a basis for discussion with each other. In order to justify why she wanted to drag a concept one learner had to explain her reasoning to the other. In this way decision making was collaborative, with the story providing the starting point of discussion. Thus, in contrast with the instance of the single learner in Example 1 who used narrative as a form of individual learning, in this case narrative was used as a collaborative feature, where learners felt encouraged to converse and where their discussion was informed by the narrative element.

So narrative appears versatile enough to be able to support both individual and collaborative approaches to learning, and works with both the cognitive and the socio-cultural constructivist perspectives.

The user experience questionnaire provides supporting evidence in this respect. The capacity of the 'Story of the product' narrative element to support learners in individual meaning making becomes apparent, since learners in both schools have marked this as one of the most useful features in helping them make decisions in the 'Case study' interactive sequences:

Which clues did you find most useful in helping you choose your moves in the game?

- *Story of the product*
- *Audio cues of concepts' meanings*
- *The image of the product*
- *Talking to the other participant about what choices to make*

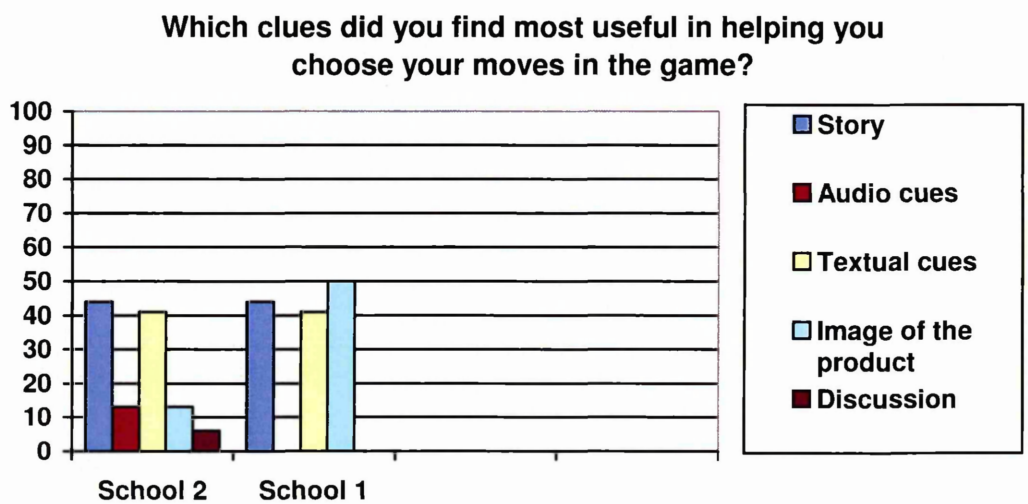


Figure 31 The potential of narrative to enhance thinking

Figure 31 identifies that narrative ranks highly in students' experience as a way of enhancing reflective thinking.

Based on this evidence, it appears that narrative is able to enhance individual, reflective learning as well as socially situated, collaborative learning. This suggests that in designing learning materials, opportunities need to be sought to interweave a narrative element within all learning interactions, whether individual or collaborative.

10.3.3. The role of direct manipulation and interactive elements in supporting both collaborative and individual learning

Matching game – 'Decomposition rates' exercise

(See Appendix 4: Explore >> Compostable >> Decomposition rates exercise)

Interactive media elements were used within the ecoWarrior learning environment, which did not predetermine collaboration or dialogue developing, however were successful in eliciting such dialogue from learners. An example of such an element was the 'Decomposition Rates' exercise – a drag and drop matching game which asks learners to make relationships between a commonly used product and its decomposition rate. What was interesting to observe, was that the interactive sequence naturally predisposed learners towards collaboration and shared decision-making:

Observation: *The camera is observing learners C. and J. They are interacting with the decomposition rates exercise. Their choices indicate that their interactions are not random - their choices are logical and well considered. When they get a choice right they make victorious exclamations such as 'Yes!'. It is interesting that since there is only one mouse, only one of them is manipulating the environment, however the other learner is just as engaged in the interaction - he was the one who exclaimed with joy when C. got an answer right. J. gradually starts to participate more actively by pointing to certain choices and giving suggestions of how to proceed.*

The learners' reactions in engaging with the 'Decomposition rates' activity indicated active engagement, where both contributed to the interactions. This was evident in their body language, shaking a fist and making victorious exclamations. Further, the way both learners were leaning towards the computer screen and the fixed attention on the computer screen - these were all signs of a significant degree of stimulus and intrinsic motivation. As discussed previously, such high degree of emotional response acts on the affective layer of learning.

Another element, which can be observed in this interaction, is that of collaboration between the interacting pair, where one learner is observing another's actions. While only one learner had control over the mouse, the other learner contributed actively with suggestions and was just as involved in the interaction as the learner who had control over the mouse. It can be claimed that this type of exercise - which uses immediate feedback on users' actions, direct manipulation, and a context to which learners can relate, lends itself well to collaboration and the development of thought in dialogue.

Once again, an element, which has not been predetermined as collaborative, is observed as facilitating collaborative work, and is successful in providing an opportunity for discussion. In a similar way to narrative as a form of instruction discussed in the previous section, the interactive 'Decomposition rates' instructional sequence does not rest entirely within a single approach to learning theory. It is instructional in its design yet it is social constructivist when in use, since it facilitates collaboration.

It appears that in order for the Decomposition rates exercise to provide the necessary stimulus and the possibility for development of an affective change in the learner it needs to be placed within the collaborative context of a pair of learners interacting.

Simulation

The 'Solar Cooker Assembly' game is a stimulating, task-oriented activity, which asks learners to assemble a solar cooker from the parts provided. This section provides an insight into the interaction patterns, which developed in learners when using the 'Solar Cooker Assembly' and gives an indication of the type of stimulus this task provides as a media element:

School 2, Session 2

(see Appendix 4, Explore >> Sustainable)

Observation: *Camera moves on to the next pair - the girls, A. and K. They are looking at the interactive game of assembling a solar cooker. They put in the aluminium reflector first. Then try to drag the rocks in, several times, and each time they return to their original location. They have put the reflector in with the* *wrong orientation. Then A. points to the screen with a rotating motion of her hand. K. rotates the reflector until the rays are pointing in the right direction. They move the glass container in the right location from the first attempt. They put the rocks in. Then K. wonders what to do with the disc. A. points to where she thinks it should be and explains to K. what its purpose is. We can say that the discourse is an explanation because A. is making a rotating motion with her finger, obviously explaining a process. They complete the game and start it again immediately.*

Learners were observed to return to the sequence immediately after they had completed it, which is an indication of a high degree of stimulus and willingness to engage with the task. Where willingness to engage and emotional response are involved, learning is more likely to become personally relevant and to result in attitude change in the learner.

The task also proves to lend itself well to collaboration. This can be attributed to the fact that the type of decision-making within the task can be resolved more successfully by more than one learner. From their body language it was evident that they discussed each choice and agreed on a solution before proceeding to an action. We can also see in this observation how learners helped each other actively with suggestions.

Once again, as with the interactive 'Decomposition Rates' exercise, the 'Solar Cooker Assembly' was not predefined as a collaborative exercise. The 'Solar Cooker assembly' is a simulation medium, typical of the cognitive constructivist approach to learning, utilising ideas of learning similar to Papert's Microworlds (Papert, 1980(b)). At the same time it naturally worked in supporting collaboration. Meaningful discussion arose. What is more, the stimulus and emotional response displayed by learners developed through the dialogue they were having with each other and through the shared decision making they both participated in.

These observations reaffirm that regardless of the approach to learning theory which a specific media element originally belongs to, the creative learner would benefit more if this medium is placed within a collaborative structure of the learning interactions. The benefits of this are in influencing the affective layer of learning, through the degree of emotional response elicited from learners, as well as in making the learning interactions personally relevant.

10.3.4. Guideline – Identifying which learning theory supports learning most effectively

Due to its flexibility, an interactive media learning environment has the capacity of supporting students who approach learning in different ways. Within this an IMLE employs a variety of media. It utilises a variety of approaches to learning theory – there are elements of cognitive constructivism, socio-cultural constructivism and instructional design. All of these elements function alongside each other in a fluid way, within the same environment. Each utilises an amalgam of instructional approaches. The choice or emphasis of one over the other, is entirely dependent on the preference of the learner or learners interacting with the environment. Such fluidity to the learning interactions and support for the student are only possible through a dynamic, flexible and versatile medium such as interactive media.

The question of which learning theory is most suited to supporting learning, is unlikely to be answered by favouring any one form of theory over any other. Instead it would be more helpful to the learner and would make an IMLE more efficient to allow for all of these approaches to learning theory to work alongside one another, where the choice and emphasis of any one is determined by each individual learner.

Evidence shows that mixing media elements originating from a variety of approaches to learning, instructional, cognitive or social constructivist, benefit learners with the versatility of affordances they make for learning. The most important condition for them to be able to support the development of learning and emotional response in the learner however is that these elements need to be situated within a collaborative structure. In this way they would be able to support both individual learning, which promotes reflection in the learner and collaborative learning, which encourages self-expression and autonomy building in the learner. With both reflection and self-expression supported, the learning environment would provide the optimal conditions for creativity to develop in the learner.

10.4. Competition versus collaboration – aspects, which influence learning

According to Underwood (Underwood, 1999) cooperative work is different from collaboration. In cooperation, learners work on separate parts of a task in order to achieve a shared goal. In contrast, where genuine collaboration exists, shared decision-making is performed.

Within the ecoWarrior learning environment, The Two Players game in particular was observed to encourage cooperation rather than collaboration between learners. In the Two Players game the actions of the participating learning pair were interdependent - for the game to proceed they had to cooperate. However the level of support for each others' thinking and the ability to build on each others' ideas was not as prominent. Within the Two Players game, learners were not observed to participate in shared decision-making, in the way that was characteristic of the Sketching tasks for example (see sections 8.3.2 and 8.3.4).

The following is an example of such cooperative learning, which occurred within the Two Players game, which did not accomplish collaboration:

Observation: *K has dragged all the concepts, which she thinks apply and is confused because she doesn't think there are any others, which could apply, yet she has not won the game. Learner A, who designed the game, is not providing any feedback and K is stuck looking at the concepts and thinking which ones could it be. She has reached a stage at the interactions, which is not helpful to learning. Learner A tries to offer reinforcement:*

A: *Go on - read them all!*

K: *I have read them!*

While K doesn't think any of the remaining concepts apply she is going over and over the descriptions trying to guess which ones might A. think it is. In reality this kind of approach does not contribute to meaning making, since the learner is relying on guesswork not on logic and her choices do not emanate from the *properties of the materials used in the product idea but from guessing in which way the other learner thinks.*

Finally K loses the game.

While both participating learners employed active reflection, learner A in designing the game, and learner K in interpreting it, no collaborative dialogue developed. Learner A did not venture any helpful hints to learner K, and learner K did not give any reasoning why she thought the rest of the concepts did not apply. The two learners did however cooperate in making the game work and engaged with the content in a reflective manner. They did not however accomplish a dialogue or a way of relating to or building on each others' thinking. While learners shared a learning problem, the thinking process each of them went through was entirely individual. No external idea exchange or sharing of different perspectives developed. As a result, there was very little opportunity for a *change* in the individual thinking of each learner. The learners' interactions with the learning environment were impoverished, benefiting only from individual reflection but not from external expression.

Following is another example of the same phenomenon:

(supporting video material available: see Appendix 5, TwoPlayers.mpg)

Researcher: *Let me say something here - if you disagree with any of the choices he's made you are supposed to discuss it.*

B: *(laughs) I put in a few random ones...right - some of them are worth two points some of them are worth one point, the other ones are worth like - zero points.*

Learner J. starts reading the descriptions. J. drags 'renewable' and gets a point.

B: *Ooh- yes! Well done J.!...I shouldn't have put so many actually. Should have left out more bad ones.*

J. drags 'abundant' and gets a mistake.

J: *What? It's abundant! Steel's abundant.*

B: *I didn't put that in actually. You may end up getting some wrong ones.(laughs) May be that was a wild card! You haven't got any of the two points in have you?*

J. opens the 'Game Rules' and reads them. This could be an indication that he feels something is wrong with the interactions if he is right but is getting punished for it and is trying to find a way out of this injustice. He goes to the line of 'you don't have to agree with all of your friend's choices' and reads it out loud. Learner B. laughs.

B: *I've made it really hard, haven't I.*

J: *Wood's recycled.*

If we compare these instances with those in which collaboration naturally occurred (see sections 8.3.2 and 8.3.4), we can see that there is a key differentiating factor, which could have an impact on the degree of learner collaboration. The Two Players game involves an element of competition, where the two learners are placed in opposition to one another, and the success of one depends on the other one losing. It this sense it is unreasonable to expect collaboration between the learners, even if they are cooperating on making the game work.

We could say that the conditions and the set up of the Two Players game as a competitive exercise can predispose learners towards cooperation, where their actions contribute to a shared goal, but not towards joint thinking, where the decision making process is shared.

This indicates that where a competitive attitude is encouraged in learners they would be more likely to cooperate rather than collaborate. This however does not provide the socially situated learning structure, to the extent, which is necessary for creativity to occur in the D&T learner (see Ehiyazaryan, Lewis & Williams, 2004 : 73).

Moreover such 'cooperative' set up can give rise to negative attitudes developing in learning. In the following excerpt a pair of learners are interacting with the Two Players game. We can observe negative emotions on the side of the learner who is losing the game, feelings of resignation and indignation where the learner feels powerless to turn the outcome in his favour:

Observation	**Conversation analysis**

Camera observes B and J engaging in the Two Players game. J has got several concepts correct and has four left to guess.	
J: *I am confused...B, you've really put some random things in.*	Learner J is experiencing confusion and inertia – he does not know how to proceed as he realises some of the choices learner B has made have been random.
B: *Oh yeah – that was the wild card. (he points at 'reclaimed' for which indeed - there is no indication in his product idea that he has or will be using reclaimed materials)That was the random one...like - eh - building sites and stuff (laughs).*	Learner B does not justify himself with logical argumentation, he admits to having misused the rules of the game to his advantage. He is not engaging in meaning making.
J. wants to give up.	An attitude of resignation deepens in the learner, as he fails to see the point in continuing.
B: *There's only four left, man! You've tried... (B is passionate about the game and does not want J. to give up. He wants to see how it turns out. There's only four left so it must be the four that you haven't tried - there's the power of logic.*	Excitement in learner B. This is motivated by extrinsic factors however and therefore not productive in terms of creativity or exploratory thought. He merely wants to see the game through to the end so he can see himself win.

J. drags randomly the ones that he hasn't dragged before and it gives him a mistake - he loses.	Resignation.
B: *Ooh - (disappointed)*	
The feedback reads : 'Well done Spartan 111 John but it looks like this is Shenobi's win. Try again!' They swap roles.	
B: *J, don't do - don't do a completely random one.*	A change in the learner's attitude is observed – even though he was the one who initiated malpractice in the previous interaction, he is unwilling to engage in it again.
J: *Really? Why would I do that.*	Sarcasm. This learner is now seeking revenge for having lost in the previous game.

As a result of learner B's randomly chosen concept, learner J has adopted an attitude of resignation - he is disheartened that he has any chances of winning this game on the basis of making logical choices, since B. has included a completely random concept. Learner J very rightly does not see the point in continuing. The attitude of resignation, which develops as a result, is detrimental to learning, and leads to apathy – an attitude which is completely the opposite of what the learning environment aims to promote.

It is interesting to observe however, that when they finish playing the game, learner B's reaction is to prevent the other learner from putting in random choices: *'Don't put any random ones in'* - this experience of the first game, which had a random choice in has made them both realise that the activity becomes unexciting and pointless when they assign random choices.

What we have at the end of their first game is a change in the learners' attitudes, where learners themselves realise the difference between meaningful exploratory play and surface interactions. Learners are regulating their own attitudes and adapt to what would produce meaningful interactions. The following excerpt is taken from the subsequent interactions of the same two learners. We can see a marked change in attitude:

Observation	Interpretation
B is playing the game, which C has designed. He enters his own name in. He drags 'durable' in but it is wrong. He protests.	
B: *What!? Have you messed them about? You have used teak and stainless steel - how do you not use durable materials?!!*	Learner B's protest is a sign that he has now started accepting the need for rules existing and does not find random choices acceptable himself.
C: *Yes I forgot to put that one in, right.*	Learner C admits his mistake, which as he says has not been a purposeful act to make the game impossible to win for the other learner.
B drags in 'sustainable' - which is correct.	

B: *Thank you.*	Positive reaction to the system's feedback.
B stops and reads all the descriptions carefully before dragging. There is no randomness or joking. He drags 'non-toxic' - it is correct.	B is taking the interactions seriously.

In this interaction, we can see that learner B is actually irritated by the possibility that the other learner may have assigned random choices. Even though it was this particular learner who was observed assigning random choices in the first session, it is him who protests against the possibility that the choices may have been random. It appeared that the other learner had not actually meant to assign values randomly but had forgotten. He corrected himself and accepted the other's protest as valid. In this way a further aspect starts to emerge as positive - that as a result of more prolonged use of the learning environment, a form of self-regulating of their attitude to the learning content has started to develop.

Such self-regulation in their attitude shows that learners have started to care more about the learning content as a result of prolonged use, are becoming more familiar with the environment, and want to elicit more from the interactions. I would argue that the motivation for such a change in their approach to learning comes out of the realisation that it would be more interesting if they could elicit meaning rather than randomly dragging. This makes an argument that learners are now intrinsically motivated to learn, and is evidence that this type of interaction, utilising the game metaphor, with a score, winning and losing, the direct manipulation interaction style, does indeed work as promoting learning, in terms of contributing to the development of intrinsic motivation in learners.

At the same time, if we look at the nature of the dialogue, which develops between learners – we can observe an immediate marked difference with the kind of dialogue, which develops as a result of the Sketching Tasks for example. The dialogue developed in the Sketching Tasks is more in-depth, follows a train of thought to a solution to the issue which has arisen. In contrast, the dialogue, which develops as a result of cooperation, where genuine collaboration is absent, seems to revolve around a disputative mode of talk, which aims to assert the authority of one learner over another. Unfortunately this is an unavoidable consequence of the element of competition being present in the interactions.

Despite bringing in the undesirable effect of competition in the learning interactions, the games design set up is undoubtedly stimulating to learners, as we can tell by their emotional response. In incorporating an element of competition, active reflective thinking is promoted. This is indicative of utilising the cognitivist learning approach. On the other hand, it was in the dialogue with each other that learners realised that they needed to self-regulate their actions. It was because of the negative reaction of learner J that learner B started to regulate his actions. In its own turn, dialogue contributed to learning.

10.4.1. Guideline - competition versus collaboration – aspects, which influence learning

The emotion which learners predominantly expressed in the instances in which they did not share in decision making were frustration at not understanding each other. In order to avoid these negative effects, a shared discussion space needs to be provided for learners. Within this discussion space the element of direct competition between learners needs to be absent, in order to allow for collaboration to develop.

However, a further phenomenon was observed regarding competition – in the course of interacting with the learning environment, learners regulated their own attitudes towards the learning interactions. After finding out that the experience was not as interesting where random choices were selected, learners became more responsible in the choices they made. This is evidence of a change in the learners' attitudes. It indicates that learners would be prone to changing their attitude to the learning material in a positive way. Yet it can be argued that this change would only take place if the learning material is engaging enough to give students a challenging and interesting experience in return.

This changes the way we see the effects of competition in a learning environment. While competition is a factor which seemed to have a negative influence on the learners initially, it is also an element which has recognised potential for providing stimulus to learners – a principle widely utilised in computer games design. This potential is part of what makes the learning experience challenging and interesting enough to be able to achieve a change in the learners' attitude. It needs to be acknowledged therefore that competition can play a positive role in learning, but it has to be used in a way which does not hinder collaboration between learners.

10.5. Conversational framework and its relationship to varieties of learning - declarative knowledge and original thought

This section explores the relationship between the type of dialogue, which is supported in learners and the type of learning outcome, which results from this. ecoWarrior targets two specific types of learning – declarative knowledge and the development of creative thought. It is undoubtedly the case that creative thought cannot develop in the absence of knowledge of the subject, which is why both *'varieties of learning'* (Gagne, 1985(b) : 46) need to be supported by the multimedia learning environment. The question is – what type of dialogic framework is able to support both of these varieties of learning optimally?

Since Laurillard's Conversational Framework is one of the most significant efforts in providing a framework for the analysis of computer mediated and supported dialogue, it is taken as the basis for analysis and evaluation in this section. The framework is explored from the point of view of its value to both types of learning - declarative knowledge and creative thought. Suggestions for adaptation are made, which make affordances for the development of autonomy and self-esteem in the learner, both of which are affective factors of learning, contributing to the development of creativity. Approaches to learning theory which are able to support either type of dialogue, are explored.

Finally, recommendations are made regarding the type of instructional form, or interactive elements in the learning environment, which best support each learning variety.

10.5.1. Conversational framework and declarative knowledge

The following example provides evidence of how the Conversational Framework was successfully used by a teacher in uncovering misconceptions in the learner's understanding:

School 1, Session 4

Researcher: *L can you talk about your choices as you are making them?*

L looks at 'renewable' and does not choose it. Drags 'recycled' and it is correct.

Researcher: *What do you think renewable materials are?*

L: *Ones that can be melted down and reused.*

Researcher: *No. Renewable materials are wood and all those, which come from a renewable source.*

L reads sustainable and does not choose it.

Researcher: *Is MDF a type of wood?*

L: *Yeah it is.*

N: *It's not is it?*

L: *Yes it is - wood chip and such - it is natural.*

Drags 'lightweight', it is correct. Drags recyclable components but it gives him a mistake.

Researcher: *Why did you think it has recyclable components?*

L: *Because I thought - he's using aluminium and I thought it was.*

In the specific example given above, the researcher, in a capacity of participant observer, found that students did not grasp the true meaning of what 'recyclable components' meant as a concept in eco design. The students' understanding was that 'recyclable components' were parts within the product, which could be recycled. In fact the real meaning of the concept is to be able to take a ready-made component from one product and use it directly within another, without the need for remanufacture. This type of misconception can be brought to the attention of the teacher successfully only if the teacher engages with and monitors the student's interactions personally, in the form of one-to-one dialogue.

The researcher intervened directly in this instance, asking focused questions about the student's actions - i.e. the choices learner L was making in assigning values. A similar approach has been described by Laurillard in the Conversational Framework, where the teacher adapts their questions to the learner according to the learner's answers (Laurillard, 2002(a)). It appears that the Conversational Framework approach has a key advantage in terms of pedagogy. The opportunity which the framework allows for learners to verbalise their thoughts, reveals any misconceptions they might have regarding the learning content and offers an opportunity to the teacher to intervene and make explicit to the learner these misconceptions.

The following example provides further evidence, this time from school 2, of the value of the Conversational Framework as providing a structure, within which the teacher can monitor learning progress and highlight any misconceptions learners may have.

School 2, Session 2
C: *Well it's made of - it will use plastic but it will use recyclable materials.*
T has put in lightweight and recyclable.
Researcher: *What do you mean by recyclable plastic?*
C: *It can be disposed of by being recycled.*
Researcher: *So it is a thermoplastic?*
T and C: *Yes.*

Similarly to the example from School 1, this is another instance of how the teacher was able to gain an insight into possible areas of misconception the students may have. In this type of interaction we have the computer as a conversation point and a structure for thinking. At the same time the teacher can see what is happening on screen and gain an insight into the students' understanding. In this way the interactions with the computer function as an evaluative tool, since the teacher now has two reference points on the basis of which to give feedback - one being what learners verbalise as their way of thinking, and the other - their actions on screen.

10.5.2. The Conversational Framework as an evaluative tool

Several features within ecoWarrior were identified which helped turn the on-screen interactions into an evaluative tool. The Assign Values tool was one such feature, which allowed the teacher to refer to the interactions on screen and on the basis of the learners' actions, provide the necessary feedback. The following example illustrates this point:

School 1, Session 4
Researcher: *L can you talk about your choices as you are making them?*
L looks at 'renewable' and doesn't choose it. Drags 'recycled' and it is correct.
Researcher: *What do you think renewable materials are?*
L: *Ones that can be melted down and reused.*
Researcher: *No. Renewable materials are woods and all those, which come from a renewable source.*
Researcher: *: Is MDF a type of wood?*
L: *Yeah it is.*
N: *It's not is it?*
L: *Yes it is – wood chip and such - it is natural. Drags 'lightweight', it is correct Drags recyclable components but it gives him a mistake.*
Researcher: *Why did you think it has recyclable components?*
L: *Because I thought - he's using aluminium and I thought it was.*

The Assign Values tool allowed for a perfect Conversational Framework type dialogue to develop between teacher and learner. The teacher used the interactions on-screen as an indication of what the student was thinking and on the basis of this had an opportunity to ask directed questions, challenging any possible misconceptions which the student may have had.

The value of computer assisted learning as a tool for evaluation has been recognised in research literature. Because of the different paces at which students move through an interactive sequence, the content delivered by a learning environment and the individual student's engagement with content often seem obscure and lost to the teacher. Brannigan (2005) maintains that rather than as a problem, computers are to be seen as an aid to the assessment and evaluation process. A computer has the capacity of monitoring and recording each step the learner is making, the amount of time they are spending on a specific sequence, the kinds of choices, as well as the kinds of mistakes they are making in engaging with the learning content – a task which is impossible to capture by traditional methods of learning material delivery.

While ecoWarrior did not have a tracking system which to allow for such monitoring, the Assign Values feature could serve very well in providing the teacher with an evaluative outlook on the learners' subject knowledge and any existing gaps in their knowledge. Both the Assign Values feature and the Materials Selection feature provided a starting point for discussion on the basis of which valuable dialogue, both learner-to-learner and teacher-to-learner, could develop. In its intuitive use of content it allows for the learner's knowledge to be revealed and makes the level of this knowledge explicit to the teacher.

10.5.3. Guideline - the Conversational Framework as an evaluative tool

While monitoring the learner's choices can be seen as running contrary to the idea of reinforcing pupils' autonomy, if used sparingly by the teacher - i.e. - teacher only intervenes with open ended questions and tries to promote discussion rather than tells the learner that their choice is wrong - it can be a powerful diagnostic tool for the teacher and a reflective tool for the student. The role of the computer in this case is in providing a structure and a record of the learners' actions and misconceptions.

One aspect, which is common to each of the instances discussed above, concerns the type of knowledge, which the Conversational Framework supports. In each of the instances discussed the Conversational Framework proved beneficial in terms of enhancing learning, in providing a tool for evaluation for the teacher and in providing a structure through which the learner could obtain external feedback. It is necessary to note that these instances dealt primarily with declarative knowledge, which generally has an unequivocal right or wrong answer. In such instances, the Conversational Framework in the form of face-to-face teacher-to-learner dialogue is truly successful.

However, within a learning environment, which ultimately aims to support original thought in the learner, declarative knowledge is only one of the essential varieties of learning which need to be supported. The following section explores the value and effect on the Conversational Framework when used in the context of originality and creativity. In a sense the Conversational Framework approach is put to the test in terms of its value to promoting original, creative thinking.

10.5.4. Conversational framework and original thought

As was identified in the preceding section, the Conversational Framework has significant potential for supporting the learner in acquiring declarative knowledge. When applied to the processes related to idea generation and the development of original thought however, the outcomes of applying a Conversational Framework approach are less convincing. The following instance provides evidence of this:

School 1, Session 2

Researcher: *Can you think of any other solutions – again – because the windowsill wouldn't be that wide. So may be something less heavy.*

A: *Well I also had that idea of like an L shape plastic holder, which you can screw onto the back – so one of those on each side – just to support it. This is as far as I got.*

Observation:

Learner A had two ideas of how to sit a solar panel in a windowsill. The exploration of these ideas was encouraged by my suggestions that positioning in the windowsill may pose a problem with ease of access to the window. A conversational framework model to the dialogue was implemented here and problem-solving learning took place:

- *The learner responded to the learning material within ecoWarrior by modifying his initial idea for a desktop light;*
- *He described his design to the researcher;*

- *The researcher questioned his design decisions and established areas which he had not yet considered in detail;*
- *As a result he produced two alternative designs for supporting the solar panel in a windowsill.*

While the learner generated his ideas in Session 2 and had the opportunity to look up different sizes of solar panels during the week, he never did. When I asked him again in the subsequent session what size of panel would power a desktop light - he still did not know the answer. Subsequently the leaner dropped this idea altogether and continued with developing a completely different one.

This is an example of how this method of teaching and instruction failed to produce the necessary conditions for attitude change in the learner, and as a result failed to produce an adequate level of originality of the idea. The learner went along with an idea in order to comply with the teacher's request.

This indicates that the learner felt the idea was being imposed on him, which in effect prevented him from taking autonomous decisions about his work and stifled his creativity. The learner was not interested enough to explore the idea further.

This instance supports the idea that strong teacher intervention at an early stage of generating ideas, even if it uses the Conversational Framework, is less productive in terms of generative thought than learner-to-learner dialogue has been demonstrated to be (see Chapter 8). The example given above is not the only supporting instance of this hypothesis - the reader can also refer to the comparison which was drawn between the outcomes of the Cutting board idea (section 8.3.4) or the Archimedes screw idea (section 8.3.2) with those of the teacher-to-learner dialogue described in Chapter 8 (section 8.3.1).

Once again, the crucial factors which determine whether the intervention of the authority figure would be productive or not are the point at which this intervention is made and the form of dialogue, which is applied. In the case discussed above the researcher's intervention came in too early in the idea generation process – the researcher in effect tried to suggest the direction of exploration to the learner. As a result the effects were detrimental to learner autonomy.

Following are two examples of reinforcing learner autonomy through dialogue. The differentiating features here are that both of these dialogues took place after the learner(s) had gone through the ideas generation process, discussing and exchanging opinions amongst themselves. Furthermore this type of dialogue followed a Conversational Framework approach, where the researcher's questions are informed by the learner's answers, thus preserving learner autonomy throughout the interaction. In the following instance learners A and K have already discussed and worked on an idea and have a sketch, when the researcher approaches them:

School 2, Session 3 **Participants:** **Researcher** **Learners K and A** **supporting video material available: see Appendix 5, BambooTableIdea.mpg**	
Transcript	**Conversation analysis**
Researcher: *What is the top bit? What is it made of?*	Exploratory – trying to understand.
K: *It's like - instead of being a roll it is flattened out. And then that fits in between two things and glues together.*	Cumulative – explains the sketch.

Researcher: *And are these just natural pieces (of bamboo)?*		Cumulative – tries to understand the idea.
A: *Yes. But we don't think that's such a good idea.*		Exploratory – makes explicit their own uncertainty about the idea.
Researcher: *Why?*		Exploratory – tries to understand the reasoning behind the learner's uncertainty.
K: *Because you can't put anything on it without it locking over.*		Cumulative – makes their thinking explicit.
Researcher: *Is this a table?*		Cumulative – tries to understand.
A and K: Yes		Cumulative
Researcher: *May be you could have a glass tabletop?*		Exploratory – suggests possible modifications.
Researcher: *How do all these come together?*		Exploratory – tries to understand the idea in detail.
A: *It's just glue*		Cumulative – makes their thinking explicit to the researcher.

Researcher: *It would take loads of glue. (they both laugh)*		Disputational – points to a fallacy in the idea.
A and K: Yes...		Cumulative agree.
Researcher: *Can you think of this and make it more minimal. In a way that it comes together but it doesn't take that much material. And it doesn't use so much glue. They take some time to think about it.*		Exploratory – suggests possible improvements.
K: *Yes - you can put one on the edge, and one on the end and one down the middle.*		Exploratory – takes the researcher's suggestion and builds on it. The reflection in action model comes into effect here.
Researcher: *Can you draw it, please.*		Encourages further exploration and action.

In this discussion the Conversational Framework approach resulted in successful progression of thought in learners. As a whole the researcher's intervention in this case was significantly more successful in comparison with the previous example of the solar powered light. This makes it necessary to ask the question: which factors enabled this success?

Firstly, the researcher only intervened towards the end of the exploration of the idea. In this way, learners had time to establish what their idea was and think of its possible advantages and disadvantages. This came across in the subsequent conversation with the researcher where learners demonstrated they were aware of the pros and cons of their idea.

Secondly, as a result of having been given time to discuss and collaboratively develop their idea, learners were able to establish ownership of the idea (Mercer, 2000 (b); Papert, 1980 (b)). As a result, learners were able to accept criticism - both learners laughed at the researcher's remark: '*It would take loads of glue.'* This was a positive sign, which indicated that learners had thought about this problem and were prepared for the criticism. Learners were then able to accept suggestions for improvement of the idea without feeling either defensive, or uncertain about its value.

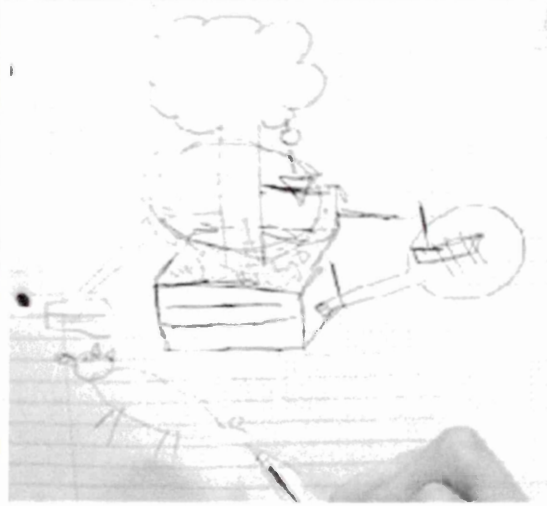
A further factor, which needs to be acknowledged, other than the time at which intervention by an authority figure is affected, is the type of conversational mode, which was adopted by the researcher. The Conversational Framework was applied, since the researcher asked directed questions, first trying to establish an understanding of the idea and further – trying to give suggestions for improvement but never imposing an idea on how learners should execute this improvement:

Researcher: *Can you think of this and make it more minimal. In a way that it comes together but it doesn't take that much material. And it doesn't use so much glue.'*

In this way the researcher is suggesting a way of thinking about the improvement, but does not offer the solution herself. This gave learners time to think for themselves. As a result they came up with the idea for improvement themselves:

Learner: *Yes - you can put one on the edge, and one on the end and one down the middle.'*

Following is a supporting example, which makes explicit the value of the Conversational Framework approach when used at the appropriate time in the learning interactions:

School 2, Session 1 **Participants:** **Researcher** **Learner J.**	
Researcher: *(to J) Can you talk me through it?*	Exploratory comment
J: *Yes. It's an apple tree and there's just a wooden box around it. That's just to put air into the compost. So when the compost decomposes all the nutrients go up into the tree which help grow apples and then the apples fall, pushing a weight on to this which pushes the air so it is pushing the air through...*	Cumulative – explains to the teacher
Researcher: *Where do the apples fall? Into the compost?*	Exploratory comment
J: *There's a big - there's a big net there (drawing)*	Exploratory – the learner continues evolving his idea as a result of the teacher's question. This is also

	reflection in action – he is drawing as he speaks.
Researcher: Oh I see...	Cumulative – positive reinforcement.
J: *In theory it works. And then they (apples) go into a slur pit - so the pigs can feed on them...and if you've got a pit board you can just press the air and get some more air in.*	Cumulative and exploratory – continues adding detail to the idea, the idea evolves as he speaks.
Researcher: *But you have to have compost in the first place.*	Disputational and exploratory – poses a further issue; uses a Conversational Framework model – the teacher's questions adapt according to the learner's answers.
J: *Yes - you mow the grass - put the grass in - I see it as a long-term thing. And then you keep going and going. Keep getting more pigs, there's more apples.*	Cumulative and exploratory – continues evolving the idea.
Researcher: *That's the most interesting idea so far.*	Positive reinforcement

The researcher's intervention used a series of open-ended questions. The researcher's questions served as a way of elucidating parts in the learner's constructed narrative account of how the composting system works, which were unclear. In this way the researcher's questions made the learner realise there were grey areas, which needed further consideration. As a result the learner came up with solutions, which he added onto his existing sketch.

So the role of the teacher within the sketching task apart from creating the relationship with actual project work, is to use directed questioning following a Conversational Framework approach, in order to make clear for the learner what the grey areas were in their design idea. Laurillard terms this external feedback on the learner's actions (2002(a)). It performs an evaluative function, but most importantly, it helps the learner develop their generative thinking. The learner did not abandon the generative mode of thinking just because of the teacher's/ researcher's intervention. In fact he continued to draw and evolve the idea as the discussion with the researcher progressed. The instance was similar to Kimbell's model of reflection in action and the interaction of mind and hand (Kimbell, 1990 : 19). In this way the learner's idea was enhanced as a result of the discussion with the researcher. Further, through the positive reinforcement, which the researcher provided, the learner was encouraged to proceed with the idea and develop this further.

In this instance, it was observed that the researcher's intervention produces a positive effect on the learner's affective layer of learning. The learner became more enthusiastic about his idea as a result of the conversation with the researcher. The Conversational Framework approach therefore worked to produce the necessary stimulus for the learner to carry on developing the idea further in the course of their discussion. The key factor, which provided the difference between the researcher's intervention in this instance and in the solar powered light, was that in this instance the idea was entirely the learner's own, and the learner's ownership of the idea was never questioned. Thus the learning interactions produced original thought since the learner accepted this as his own idea.

10.5.5. Guideline - Conversational Framework and original thought

In a learning environment which aims to influence creativity, a differentiation needs to be made between the learning instances concerning declarative subject knowledge and the broader learning base, which is concerned with cognitive strategies and attitude change, and which more directly influence creativity. While both of these types of learning are necessary to creativity, it is the view of this research that they require fundamentally different modes of delivery, specifically in the form of dialogue, which takes place. If we accept that dialogue is an essential part of the act of learning (Vygotsky, 1978 ; Mercer, 2000(b), the major difference in modes of delivery concerns the difference of the type of dialogic content and the nature of the dialogic participation, which is required from teacher and learners.

In the instance of factual / declarative knowledge, the dialogue required needs to be focussed on understanding and memorising facts. In this way the pedagogical function on the side of the teacher would be, much like in traditional modes of delivery, to examine / test the learner in the depth on their understanding and knowledge of the subject, as well as to bring to the surface any misconceptions which the learner may have. As it becomes clear from the example given above, the Conversational Framework proposed by Laurillard is a successful way of achieving this.

However, where the purpose of dialogue is to encourage attitude change and thus affect creativity in the learner, one of the positive outcomes of dialogue was identified as enabling learner autonomy and reasserting learners' self-esteem. The Archimedes screw dialogue (section 8.3.2) and the Cutting board idea dialogue (see section 8.3.4) both reaffirm the point that learner autonomy is allowed to develop more fully in the conditions of learner-to-learner dialogue, where teacher supervision and feedback are restricted to specific points in the interaction.

In effect both types of knowledge are necessary for a complete learning experience and cannot function adequately without one another. Subject knowledge in itself is not sufficient for the development of original thought, and imaginative thinking without subject knowledge would lack the essential grounding necessary for detailing a design idea. Accordingly the two different types of dialogue, which these types of knowledge require need to be equally well supported.

The Conversational Framework works well when applied to explicit knowledge, or subject knowledge where the teacher is able to identify misconceptions of learners in interpreting the subject matter and to intervene with appropriate suggestions. Such intervention had a positive impact on learners' motivation since external feedback was received.

However its role in the learning interactions becomes more complex to define when applied to the context of original ideas and creative thought. The difficulty arises once again from the necessity to preserve learner autonomy intact. As the examples of data given above indicate, a teacher's intervention in directing the progress of generating design ideas is not necessarily as productive as instances in which learners are allowed to engage in learner-to-learner dialogue.

At the same time, however, a teacher's intervention towards the end of learner-to-learner dialogue proved to have consistently positive consequences in providing learners with external feedback and reaffirming the value of their ideas. Learners responded readily and enthusiastically when asked to explain their ideas, specifically when such teacher intervention took place after learners' ideas had been fully formed. In these instances the Conversational Framework worked well to provide a structure for the teacher-to-learners interaction. The teacher was not leading the discussion in an authoritarian way but was responding and adapting to the already developed students' ideas. In all the cases where a Conversational Framework was used in this manner and at the end of the idea generation process, the teacher's intervention proved to be enriching to learners' ideas.

Chapter 11. Conclusions

11.1. Introduction

This chapter outlines the key findings of the research and summarises the original contributions to knowledge made. In each case, this research notes the findings which appear most significant in impacting learning, and in enhancing creativity. Whilst these broad areas clearly relate to the existing research literature (see sections 1.2; 2.1.3 and 2.3), in each case I believe there are new contributions to knowledge made by this work. These contributions are emphasised accordingly (section 11.3).

The chapter concludes with a discussion of the limitations of the study. This leads to identifying possible areas for future work, including a brief discussion of the practical implications for future development of IMLEs in D&T education.

11.2. Key areas of investigation and key findings

Areas of investigation

The focus of this research has been the use of interactive media to enhance learning and creativity within the subject area of Design and Technology. Research aimed to identify specific conditions of learning and principles for design of IMLEs which would support D&T students in learning and creativity. Accordingly, the findings of research contribute to furthering knowledge in the fields of both D&T education and learning technology. The major audiences, which research addresses, are educators, D&T subject specialists, as well as developers and researchers of interactive media for learning.

A series of three phenomenological studies of D&T students' learning needs were carried out, aiming to establish their knowledge, attitudes and interests where creativity was concerned. A list of requirements for an interactive learning environment was derived from the interviews which informed:

- Aspects of instructional design
- The approach to learning theory
- The interaction style
- The nature of the interactions with the computer

- A necessary collaborative element
- The learning content

Having thus established a firm empirical basis for the design of the learning environment, the analysis of the phenomenological studies identified the key areas of research. These areas were based on students' learning needs, as well as on the basis of the literature review. They can be summarised as:

- Learner autonomy
- Collaboration
- The role of dialogue
- The role of the learning environment
- Attitude change

The primary purpose of the ecoWarrior learning environment was to act as a tool for researching these key areas and understanding the extent to which interactive media could make a difference. Therefore the outcomes of research were targeted at eliciting the optimal ways of designing interactive media and using it in the classroom for enhancing learning and creativity in Design and Technology.

The evaluation of the ecoWarrior learning environment therefore held the key to understanding how to improve practice in learning and teaching with interactive media, where creativity was part of the learning outcomes.

The following section states the key findings of research organised in five clusters.

Key findings

11.2.1. Learner autonomy

Interview data from all three Learning Needs interviews suggested that students often struggled to identify a context to work within, when faced with a self-directed project. This supported the findings of the Nuffield QCA investigation into creativity (Rutland and Barlex, 2002). The focus group interview data revealed that a strong intervention by teachers was present in providing project contexts for students to work within (section 5.3). Teachers were acting as instructors, not facilitators of learning. The data analysis of the interviews pointed to a relationship between such teacher intervention and a diminished level of autonomy in learners.

Furthermore, with reference to learner autonomy, evidence from the Learning Needs interviews pointed to the value of collaborative discussion amongst learners, and its direct relationship to creativity (section 5.2).

Finally, the literature review suggested that interactive media is more capable of providing a non-authoritarian learning environment within which learners were encouraged to take creative risks (Adams, 1973; Becta, 2001). Thus the need for reassessing the respective roles of teacher, learners and the interactive learning environment in supporting learner autonomy emerged as an important issue to address in the Learning Needs interviews.

The evaluation of ecoWarrior pointed to specific evidence on the subject. Both teacher-to-learner and learner-to-learner dialogues were recorded and analysed through conversation analysis and by using Mercer's classification of types of talk (sections 2.1.4 and 7.7.2). Following is a summary of the findings regarding the respective roles of teacher, learner and interactive learning environment in supporting learner autonomy.

The role of the teacher in supporting learner autonomy

A pattern was observed as developing in the pedagogical potential of teacher-to-learner dialogue, depending on the stage of designing at which the teacher intervened as well as on the timing within the curriculum structure, in which such intervention occurred. Where strong teacher intervention occurred early on in the process of generating design ideas, evidence indicated a negative effect on the learner's autonomy and ability for self-directedness. This in turn diminished the opportunity for the learner to develop original thought. Evidence of this can be found in sections 8.3.1 and 10.5.4.

Research considered the possible motivating factors which made it necessary for the teacher to adopt a more controlling, authoritarian role towards the learners. The key emerging factor was timing. In the majority of the instances observed, teachers adopted a more authoritarian approach to teaching towards the end of a project, where the time for completing the project was critical. As the teacher is responsible for learners delivering high quality assessable work, they are bound to be extrinsically motivated, and the outcome of the project in terms of creativity and originality remains low on the agenda.

Alongside this however, a number of instances were identified in which teacher intervention played a positive role in providing feedback to an already generated idea, and thus reinforcing learner autonomy.

Key supportive instances were the teacher's intervention in the 'Cutting board idea' dialogue (section 8.3.4; see Appendix 5, Teacher intervention2.mpeg) and the 'Bamboo Table idea' dialogue (section 10.5.4; Bamboo Table Idea.mpeg). While in both instances dialogue was almost exclusively learner-led and the idea was developed by learners in collaboration with one another, learners reached a stage where they needed to communicate the idea to someone external to the idea generation process. The teacher's intervention proved necessary and productive as a way of providing the much needed external feedback and reinforcement to learners.

A further identifiable point at which teacher intervention was necessary was at the very beginning of the idea generation process. On several occasions the learners needed the teacher's reinforcement and encouragement to engage with the task (see Appendix 5, Teacher intervention2.mpeg; Teacher intervention3.mpeg).

A further instance was the positive effect of making the learner an expert in the learning situation, where the teacher played an active role in encouraging this to happen (section 8.3.5).

The role of learner-to-learner dialogue in supporting learner autonomy

A fundamental difference was observed in learner-to-learner dialogue as compared to that developing with a teacher. In learner-to-learner dialogue, when discussing a design idea, one learner would adopt the role of challenging the idea and offer new perspectives for consideration and the role of the other would be to offer alternative solutions accordingly (section 8.3.2). While the danger of such an approach was that learners could have fallen into a disputative mode of dialogue, each blindly defending their own point of view, this never happened. Learners collaborated and contributed to the idea equally. It appears that the equality of the relationship, none of the participants in the dialogue had authority over the other, allowed learners to gain confidence in the idea, exercising a high level of autonomy over the learning situation (see sections 8.3.2; 8.3.3 and 8.3.4).

Particular evidence of learners gaining more confidence in the idea after having discussed it amongst themselves, can be found in the Cutting board idea dialogue (section 8.3.4). At the point at which a teacher intervened in the learning interactions in order to provide external feedback, learners displayed a significant difference in their attitude. Because learners had discussed the idea to some depth and given each other feedback and reinforcement repeatedly, they displayed confidence in describing the idea to the researcher. Through collaborative discussion, learners had acquired more confidence in the value of the idea. On this basis, research makes the claim that the feedback which learners give to each other can play an important role in students' development as autonomous learners.

The role of the interactive learning environment in supporting learner autonomy

While the importance of learner-to-learner dialogue was emphasised, it needs to be acknowledged that the learning environment plays a significant role in supporting learner autonomy in its own right. Evidence pointed to the key characteristics of the interactive learning environment which made such a contribution.

By the nature of its tasks and the structure of the learning interactions, the learning environment encouraged collaboration amongst learners. This facilitated 'productive overhearing' and a 'listening approach to dialogue' (Cook, 2002 : 6) to occur with positive results (section 8.3.4). The role of the IMLE was to facilitate collaborative interactions and trigger them, as well as to provide content around which they should evolve. The dialogue which occurred between learners in the 'Archimedes Screw idea' and culminated in them arriving at an interesting idea for a compost bin provides a prime example of both the importance of such dialogues and the value of the learning environment as providing the necessary conditions for such learning to occur.

Further the dialogue of the 'Cutting board idea' which started as an interaction between two learners and a computer and evolved as a discussion among three learners, led to the development of an interesting idea. This makes it necessary to consider that the learning environment needs to be flexible enough and blend in with the learning setting sufficiently to allow for such flexibility of the interactions and for such spontaneous dialogue to emerge. In turn, such dialogue allows learners to develop their ideas independently from the teacher.

Secondly, the interactive learning environment provided a structure for the learning interactions, which was non-linear and discovery based. Thus learners had the opportunity to choose and tailor their paths of interaction within the learning material (sections 8.2.2; 10.3). The value of the discovery approach to independent learning and learner autonomy became evident in the ecoWarrior evaluative sessions where learners who chose their own paths of interaction, rather than allowing themselves to be led through a sequence in a linear way, displayed a higher level of engagement (section 8.2.2). It was usually these learners who engaged in productive dialogues which resulted in original thinking. This approach enhances autonomy in the learner by allowing them to consider what they themselves are interested in and how they would like for their learning experience to be tailored. In these terms the approach to learning is user-centred with the individual's learning needs at the heart of the learning experience.

Learner autonomy - conclusions

The conclusions drawn regarding learner autonomy were the following:

- In addressing a learner, a teacher is partly extrinsically motivated by the necessity to bring learners to a stage of successful completion of their project work. In this way a teacher is inclined to look on a student's project from a more pragmatic point of view. While such an attitude is necessary for a project to be successful, it is not always the optimum approach for enhancing creativity.
- In order for teacher intervention to contribute to the creative process of idea generation without compromising learner autonomy, it needs to be carefully timed. Teacher intervention was observed to be most productive after learners had generated the idea and had discussed it amongst themselves, thus giving each other some confidence in the idea before introducing it to the teacher. However, it is important that teacher-to-learner dialogue is maintained, as it is vital to providing external feedback on learners' ideas. If introduced at the appropriate time, such feedback from the teacher will in fact contribute to developing learner autonomy.
- Learner-to-learner dialogue promotes learner autonomy by allowing learners the opportunity to develop and discuss creative design ideas without significant help from an authority figure. Within such discussions, the equality of the relationship between these learners makes it possible to engage in critical, exploratory thought. Learners gain confidence in their thinking through comparing thoughts with each other, exchanging ideas, working out new solutions. As a result when learners subsequently discuss ideas with their teacher, their confidence in the idea is strengthened by the feedback they have given to each other in dialogue. This leads to the conclusion that learner-to-learner dialogue is unique in its potential to support learner autonomy.
- The interactive learning environment needs to support collaboration, dialogue between learners and productive overhearing – all of which are natural and authentic phenomena within a classroom setting. In promoting such collaborative interactions, the learning environment becomes an essential part of promoting autonomy in learners – their ideas are grounded in their own interests, and develop without significant intervention from an authority figure.

- The non-linear nature of the interactive learning environment allows learners a greater flexibility in tailoring the learning experience to their specific learning needs and interests. In this way learners have more possibilities for establishing their own cognitive space within the learning environment and for making learning their own. This is a further step to becoming autonomous learners.

Several key ideas emerge as necessary in the learner's creative development. Firstly the need for collaborative dialogue to develop between or amongst learners – this contributes to learner autonomy, particularly in making the learners' ideas independent from the intervention of an authority figure. Secondly – the role of the teacher, which when used appropriately, at the right time in the learning interactions and in view of preserving learner autonomy, provides much needed external feedback to learners. Thirdly, where an interactive learning environment is concerned, this environment needs to be able to support collaboration between learners. Further, the flexibility of its non-linear nature needs to be utilised in a way which supports students' individual learning needs.

It is evident that each of the findings related to the issue of learner autonomy point to the necessity of collaboration to be maintained in the learning interactions. The role of the teacher as well as that of the learning environment is to support collaboration in learners, in this way empowering them by promoting their autonomy. Learner-to-learner interactions are primarily concerned with the ability to collaborate and the beneficial effects which such collaboration has on students both in terms of learning and potential for creativity.

The following section focuses on findings related to the effects of collaboration on learner creativity.

11.2.2. Collaboration

As the previous section made explicit, learner autonomy stands as an important factor in developing creativity in the learner. In the context of this research the term *autonomy* refers to the relative independence of thought from a teacher or an authority figure, which needs to be further conditioned by collaboration with other learners. As the findings related to autonomy make evident, the respective roles of teacher, learners and learning environment where learner autonomy is concerned, all involve supporting collaboration and an evolving dialogue between learners. The cluster of findings described in this section foregrounds the value of collaboration within an interactive learning environment which aims to promote creativity in the learner. As in the previous section, the findings are grouped regarding to the respective roles which learners, teacher and learning environment have in supporting collaboration.

Collaboration and developing thinking

The Learning Needs interviews pointed to evidence that learners' cognition develops while verbalising thoughts. The act of speaking helps learners' ideas to develop further (section 5.2.1). The findings of the ecoWarrior evaluation pointed to similar evidence. Collaboration in the form of dialogue with both peers and teacher, contributed to learning. Evidence of this can be found in chapter 10, section 10.2, where a number of instances were described in which learners used collaboration and dialogue as a way of developing a thought. This was usually supported by individual work on the side of the learner and individual thinking – this aspect will be discussed further in the chapter.

Further evidence that thinking developed in collaboration, was that some of the most interesting and creative ideas within the ecoWarrior evaluative sessions developed as a collaborative effort (sections 8.3.2; 8.3.4; 10.5.4). As in the Learning Needs interviews' findings therefore, collaboration emerges as necessary for the development of thinking and often results in creativity.

Collaboration and seeing things from a different perspective

The Learning Needs interviews suggested that in collaborative dialogue, learners benefit from discussing different perspectives on the same topic. Such variety of opinions is invaluable in terms of creativity, since it facilitates seeing things from a different perspective (section 5.2.2).

Within the evaluation of ecoWarrior the benefit of learners exchanging ideas and sharing different perspectives on a topic was confirmed. The 'Cutting board idea' dialogue in particular confirmed this, where the intervention of a third learner in an already ongoing dialogue contributed to the discussion by bringing in a new perspective on the topic discussed (section 8.3.4). The discussion became more intense and lively with the intervention of a third learner and resulted in learners detailing the idea further and in their own words 'getting somewhere' with it. Overall the intervention had positive outcomes in terms of how creative the final idea was.

The nature of the third learner's intervention can be described as productive overhearing, as defined by Cook (2002 : 6). As it appears from the findings of this research, productive overhearing is a form of learning participation which can support creativity. In the discussion of learner autonomy, the need for the learning environment to facilitate the natural flow of the learning interactions was already discussed. The need for the learning environment to be able to support the sharing and exchange of different perspectives reaffirms this as a requirement for the learning environment.

Learner-to-learner collaboration – a unique form of communication
The Learning Needs interviews suggested that collaborative discussion between peers allows for a unique form of feedback to be shared. Feedback from other learners is beneficial in the honest, uninhibited and spontaneous qualities it has, as well as in being free from the constraints of authority (section 5.2.3). Such feedback contributes to reasserting learner autonomy. Learners' interactions with each other and with the ecoWarrior learning environment provided supportive evidence in this respect.

Within one of the most successful collaborative dialogues which developed in the evaluative sessions, learners were observed to work without raising the issue or claiming ownership of the idea (section 8.3.3). In this sense the idea was collaborative, free of competition and the issue of ownership never arose. Research relates the kind of collective ownership of the idea which learners adopted to intrinsic motivation – the learners' primary motivation in discussing and developing the idea seemed to be to improve the idea itself. These findings led research to believe that learner-to-learner collaboration does indeed have unique potential as a form of communication. Learners are intrinsically motivated, and are ready to work on an idea for the sake of achieving a more accomplished solution. Such an attitude to the work is more likely to result in creativity than any externally motivated approach could achieve.

The role of the learning environment in supporting collaboration

The Learning Needs interviews suggested that the role of the learning environment in supporting collaboration was in providing a structure to the learning interactions which encourages and enhances collaboration and dialogue developing amongst learners. Any interaction with the computer needs to serve the purpose of promoting dialogue and discussion amongst learners (section 5.2.4). These findings reaffirm those regarding the role of the IMLE in supporting learner autonomy (section 11.2.1).

The Learning Needs interviews suggested that specific characteristics of the learning environment can contribute to learner collaboration. This initial suggestion was evaluated through the design and use of the ecoWarrior learning environment. Evidence showed that in some of the key elements and features of the IMLE, for example the quiz feature, the simulation activities, the narrative elements, their capacity for supporting collaboration was of key importance where learning and creativity were concerned. In the use of simulation for example (section 10.3.3) the task could be resolved more successfully by using collaboration.

Thus evidence suggested that the value of the learning environment would be greatly increased if its constituent elements supported collaboration.

Collaboration – Conclusions

As is becoming evident collaboration and autonomy are not contradictory terms in the context of creativity. As was explained earlier autonomy within this research is a term describing the relative autonomy of learners from a teacher. In such circumstances where the learner's confidence in their own ideas needs to be supported, collaboration emerges as a much needed support system for the learner. In collaboration learners are simultaneously less dependent on an authority figure and able to benefit from feedback from other learners. Evidence established that such feedback is enriching with the different perspectives it brings to a discussion and unique in the form of uninhibited communication which it promotes. What is more, learner-to-learner dialogue is a form of collaboration which contributes to the development of the learner's thinking, which is necessary for the further development of creative thought.

In support of this argument for the relationship between collaboration and autonomy, the findings related to learner autonomy pointed to collaboration as being one of the key necessary functions of the interactive learning environment in supporting learner autonomy (section 11.2.1). The conclusion therefore is that learner autonomy can thrive most successfully when the necessary structures facilitating learner-to-learner collaboration are in place.

The role of dialogue started to emerge in this section as important specifically in allowing the learner's thinking to develop in the learner when verbalising thoughts. The following section discusses findings related to the role of dialogue to learning and creativity.

11.2.3. The role of dialogue

While in this research collaboration was established as having distinctive benefits to the learner, it is necessary to consider that such collaboration most often took place in the form of dialogue. The set of findings in this section refer to the role of dialogue in particular, where learning and creativity are concerned.

Supporting collaboration and autonomy

Both the sections on autonomy (11.2.1) and that on collaboration (11.2.2) emphasised the significance of learner-to-learner dialogue.

The role of learner to learner dialogue to promoting learner autonomy became evident in learners adopting different roles - in this way neither one of the learners had authority over the other since each performed a specific function, contributing to their shared goal. It is possible to claim therefore that learner autonomy is preserved in this way. The specific role of dialogue within this was to allow for this form of collaboration to develop between learners. As it was observed in the Archimedes screw idea dialogue (8.3.2), learners went through a process of disputational, to exploratory, to cumulative talk, incrementally improving the design idea and it was the dialogue between them which made this process possible.

Where collaboration was discussed (11.2.2), learner-to-learner dialogue emerged as contributing to the following positive effects on learning:

- Providing a unique form of feedback, such as is more likely to develop between peers;
- In collaborative discussions ownership of the creative idea could be described as collective rather than personal, learners' primary motivation being to improve the idea.

It was evident therefore that the positive aspects of learner collaboration and of reinforcing learner autonomy would not be possible without dialogue. In this sense dialogue can be seen as a vehicle for both learning and creativity.

Declarative knowledge and creative thought

Alongside its ability to support collaboration and autonomy, a further important function of dialogue was established as its capacity to support different types of learning. The complexity of creativity in an educational context was already discussed in the literature review (Chapter 1). The section on the Conversational Framework (section 2.1.4) in particular emphasised the need for two different types of learning to be supported – declarative knowledge and creative thought. The findings of this research point to a correlation between the type of dialogue and the type of learning which is supported. In Chapter 10, the value of the Conversational Framework, which implies dialogue, was explored in respect of declarative knowledge and creative thought. The findings pointed out that a dialogue between teacher and learner was more successful in its capacity to facilitate the learning of declarative knowledge. Dialogue between or amongst peers however was observed to facilitate creative thought. As a result, while the Conversational Framework's value remained undisputed, it was the participants in the dialogue which determined which type of knowledge would be better supported. Peer-to-peer dialogue, which uses open ended questions and places one learner in the role of posing an idea, and the other learner challenging this idea and bringing in new suggestions, is more likely to enhance creative thought. Teacher to learner dialogues adopting the Conversational

Framework of open ended questioning is more likely to be successful in supporting declarative knowledge.

Developing thinking through dialogue

Evidence from the Learning Needs interviews suggested that verbal expression is beneficial to developing the learner's thinking (section 5.2.1). Findings from the evaluation of ecoWarrior supported this with further evidence (section 10.2). Examples were given of learners consistently supporting their individual work with a form of dialogic discussion. What was interesting to note was that in the majority of the cases learners engaged in such discussion in order to express a personal preference. This need for self expression through dialogue can be most accurately described as belonging to the affective layer of learning. As discussed by Gagne (1985(a)), the affective layer of learning was identified as coming closest to supporting creativity. Dialogue is therefore serving the function of a form of self expression which can be creative as its purpose is affective in nature.

One of the implications which this made was for the design of the interactive learning environment. Since dialogue and individual work emerged as interdependent, dialogue as impacting on the affective layer of learning, and individual learning as a reflective tool, this gave an indication of how various elements of the learning environment could be optimally designed to support both forms of learning. These indications are discussed in section 10.3.

The role of dialogue – conclusions

The findings of this research point to the role of dialogue as being first of all to support collaboration and support learner autonomy. In allowing for learner-to-learner discussions to develop, dialogue supports a collaborative approach to the work in this way contributing to learner autonomy.

Secondly, the nature of dialogue was established as determining the kind of learning, declarative knowledge or creative thought, which would be supported. Learner-to-learner dialogue was related to creative thought, while teacher to learner dialogue was more successful in benefiting declarative knowledge.

Finally, an important function of dialogue emerged as that of self-expression. This establishes a direct relationship between dialogue and the affective layer of learning. Dialogue was always combined with individual work and reflective thought by learners. This gave a strong indication that an interactive learning environment needs to be able to support both individual reflection and collaborative dialogue in order to allow for creativity to develop.

As is evident each of the clusters of findings discussed so far makes implications for the optimal design of an interactive learning environment. The following section combines these implications with evidence, in order to discuss the findings which relate to essential functions of the interactive learning environment.

11.2.4. The role of the interactive learning environment

Since this research is essentially an exploration of the value of interactive media for supporting learning and creativity, it is natural that this section, describing the role of the interactive learning environment, relates strongly to each of the clusters of findings so far discussed. This section makes explicit the role of the learning environment in:

- Supporting learner autonomy
- Providing flexibility
- Influencing attitude change

The role of the learning environment in supporting learner autonomy

In discussing the role of the interactive learning environment, priority needs to be given to the issue of promoting learner autonomy. As already discussed in the literature review (Hennessey and Amabile, 1988; Rutland and Barlex, 2002) a creative attitude to work depends heavily on promoting learner autonomy.

The findings of this research pointed to a unique quality of the interactive learning environment which contributes to promoting learner autonomy. The structure of an interactive learning environment, where content is hyper-linked, can be described as non-linear. This non-linearity allows learners to tailor the learning experience according to their own personal learning needs. Being able to choose the learning content they interacted with according to their own personal interests, became an indication of the level of independent thought and autonomy of the students.

This relationship between the level of learner autonomy and the way learners interacted with learning content was most obvious in the way they used navigation. Sections 8.2.1 and 8.2.2 made explicit that in the course of using the learning environment students progressed from using linear next-back button navigation to using navigation by topic or function. Such a progression was an indication that students were becoming more engaged with the learning content and more selective in what they would view. Students had achieved what was described by Bekier as establishing their own cognitive space within the learning environment (Bekier, 2005). Therefore, the way students used navigation became indicative of the depth of their learning interactions.

Two aspects concerning the navigation tool of an interactive learning environment became clear:

- The navigation tool needs to provide different pathways through content, catering to the individual learner's needs;
- The way students navigate could be used as an evaluative tool by teachers.

The most important aspect which emerges in the use of navigation therefore is its flexibility in accommodating the student's learning needs. This leads to the next key role identified for the learning environment - that of flexibility.

A flexible learning environment

In the two most creatively successful instances of collaborative work analysed in this research (sections 8.3.2 and 8.3.4), the key, facilitating factor identified was the dialogue which took place among learners. Considering that learners' interactions were prompted by a computer based learning environment, the ability of the system to afford social contact, collaboration and spontaneous discussion to emerge was the IMLE's most valuable feature. This ability of the computer based learning interactions to afford collaboration is what can be referred to as the flexibility of the learning environment. With such flexibility in place, learners' face to face communications are encouraged and the fluidity of the interactions and discussions which naturally occurs within the D&T classroom is preserved.

Further to the need to support face-to-face collaboration, the flexibility of an interactive learning environment was also determined as necessary where the approach to learning was concerned. Stemming from the debate on the approach to learning theory which is most appropriate to adopt (section 2.3), the issue emerged of collaborative or individual learning approaches. The findings of research indicated that the collaborative and individual approaches to learning were used by learners simultaneously on most tasks. In relation to this, some of the key elements of the interactive learning environment were evaluated in terms of their ability to support both collaborative and individual approaches to learning. The elements evaluated were:

- The quiz feature (section 10.3.1);
- Narrative (section 10.3.2);
- Matching game ("Decomposition rates" exercise) (section 10.3.3);
- Simulation ("Solar cooker" game) (section 10.3.3).

Evidence emerged that each of these elements was able to support both collaborative and individual learning. In this way the findings of research suggested that mixing media elements originating from a variety of approaches to learning, instructional, cognitive or social constructivist, benefit learners with the versatility of affordances they make for learning. However, the most important condition for them to be able to support the development of thinking and emotional response in the learner was that these elements needed to be situated within a collaborative structure. In this way they would be able to support both individual learning, which promotes reflection in the learner and collaborative learning, which encourages self-expression and autonomy building in the learner. With both reflection and self-expression supported, the learning environment would provide the optimal conditions for creativity to develop in the learner.

The role of the learning environment in providing differentiation

The findings of research pointed out that learners with low subject knowledge combined with low motivation and lack of interest in the subject would not be able to benefit as fully from the self-directed nature of an interactive learning environment. Instances were observed where such learners did not manage to engage with the learning content, often losing sight of the goal of instruction (section 9.4.1). This resulted in lack of participation and an inability to construct new meaning.

In such circumstances a more linear, strongly instructional approach was identified as more appropriate with a heavy involvement of the teacher as providing guidance and feedback at key stages.

This concern for meeting the learning needs of students of varying ability and motivation for the subject brings to the fore the issue of differentiation. Differentiation by task was identified as a possibility for interactive media to implement. Such differentiation could be achieved by utilising the flexibility of the digital medium and providing different pathways through content. According to their motivation, ability and interest, learners could choose whether to use a more structured approach of linear presentation or a discovery oriented approach.

Differentiation by task also concerns the type of task given. ecoWarrior provided sketching tasks, which while accepted as a standard form of generating ideas and recording thoughts was problematic, since only those learners who could draw and were confident in their skill would be encouraged to participate. Thus the findings of research identified the need for alternative forms of task provision, involving dialogic tools, mapping down verbal discussion in the form of notes, or using small scale 3D modelling.

Influencing attitude change - personalisation

As the previous section discussed, alongside the need for supporting reflection in the learner, there is also the need for supporting self-expression, thus influencing the affective layer of learning. Apart from dialogue as a tool for self expression, the findings of research pointed to several features of the learning environment which had the capacity to support affective change. Such features were:

- The Name Entry feature (section 9.2.2)
- The Assign Values feature (section 9.2.3)
- The Materials Selection feature (section 9.2.4)
- Narrative features (section 9.3)

The capacity of these features to support affective change in the learner was referred to as *personalising learning*.

The Name Entry feature personalised the interactions by alerting the learner to the fact that any interactions they undertook would impact on and be considered their own work.

The Assign Values feature personalised the interactions by involving the learner in manipulating an image of their own work on screen.

Finally, the Materials Selection feature made learners consider this same work in the context of previous knowledge on materials properties.

Narrative elements within the learning environment displayed the capacity to elicit an emotional response from learners in this way changing the way students perceived the subject – sustainable design, as well as the subject's meaning to their own design work (section 9.3).

The findings of research indicated that when the learning interactions became personally relevant to the learner, learners displayed deeper engagement with the learning content, in some cases indicating a change in the affective layer of learning, i.e. – a change in attitude, as identified by Gagne to be closely related to creativity (Gagne, 1985(a)). The findings of the Learning Needs interviews in their own turn suggested the need for context rich content, which needs to be inspirational as well as stimulating to learners. Finally, these findings are supported in the research literature, where the need for stimulus emerged as one of the key conditions for creativity (section 1.2.3).

The role of the learning environment in supporting learning and creativity – conclusions

The findings of research made clear that there are two characteristics of an interactive learning environment which make it a unique and valuable learning tool – these are flexibility and personalisation. The flexibility of the interactive medium, applied through hypertext and through the non-hierarchical nature of the way content is organised, allows learners to tailor the learning experience according to their own learning needs and interests. This contributes to promoting learner autonomy by encouraging learners to take control over the shape and direction of the learning content they engage with.

The flexibility of the interactive learning medium also refers to the ability of the learning environment to support both individual and collaborative approaches to learning. Several interactive learning features were evaluated, including quiz, narrative, simulation activities, matching game. While each of these could easily work as an individual activity, their true capacity for eliciting learning from the students was in supporting collaborative work alongside individual reflection. This makes explicit the value of interactive media to learning. Its ability to adapt to a natural learning setting, without disrupting, but rather by bringing together reflective and collaborative thought, is what makes it a valuable and successful learning tool.

As in all the rest of the roles which were identified for interactive media, differentiation too is enabled by the flexibility of the learning environment. Its flexibility works by allowing learners to engage with content in either a linear, structured way, or to choose a more selective, discovery oriented way of viewing content, tailored to their specific interests. Within the learning environment these choices can be made without having to single out and group students according to their level of ability, in this way avoiding any negative effects this may have on their self-esteem and confidence. Furthermore, this same flexibility allows for the type of task to be chosen by the learner according to their learning preferences.

A number of features were identified within the learning environment, which were able to support personalising learning. Personalising learning is important in its ability to support attitude change – the more personally relevant the learning content is to the student, the more likely they are to learn, as well as to experience a positive change in their attitude towards the subject studied. This research has made evident therefore that elements of interactive media which in themselves are quite simple, if used appropriately can make a difference in influencing attitude change in the learner. As the literature review made explicit, attitude change is the learning capability most closely associated with creativity. Therefore elements such as name entry and menu selection can be seen as influencing learner creativity.

11.2.5. Attitude change

Within the evaluation of ecoWarior there were a few examples where a positive change in the learners' attitude towards the subject and towards their own work, were evident. While few in number, these examples are considered to be significant since they provided an insight into the specific aspects of the use of an interactive learning environment which would be able to contribute to a positive change in the learner's attitude. Such a change is considered valuable as it is a stepping stone for the further development of creativity in the learner.

Key findings on autonomy, collaboration, dialogue and the role of the learning environment have already been discussed. This section discusses evidence of the potential contribution of these to attitude change.

The strongest evidence towards attitude change was observed in the Two Players game where learners displayed signs of understanding the difference between meaningful exploration and surface interactions (section 10.4). As a result learners moderated their attitude and started taking the learning content more seriously, leading to meaningful engagement with this learning content. Having understood that the learning interactions would benefit them more, as well as being more interesting if they took them seriously, learners changed the nature of their interactions. This is an example of attitude change in learners as a result of engaging with the learning interactions. The benefits of such attitude change are in learners becoming more autonomous and intrinsically motivated in their work – the two key contributing factors to creative development.

Further indications of attitude change in learners were found in the way learners related to the issue of ownership of a design idea, when this idea was developed collaboratively (section 8.3.3). The discussion on findings related to collaboration already made explicit the value of collective ownership over individual ownership of a design idea. Besides denoting intrinsic motivation and therefore a link with creative thinking, such preference on the side of learners for collective ownership indicates affective change, where learners have placed the development of an original concept over the concerns of ownership.

The ability of the interactive learning environment to elicit an emotional response from the learner also shows potential for attitude change to take place in the learner. Four key factors were identified for such emotional response to lead to attitude change:

- The need for learning content to be dynamic, stimulating, unusual and interesting;
- The need for the teacher to situate the content in the authentic activities of the subject setting;
- The need for student led discussion with peers;
- An activity which offers opportunities for creative response.

While there is no concrete evidence to suggest that learners experienced a change in their attitude, it is possible to assert a change in the affective layer of learning – learners responded positively in a situation where all of these factors were present, displayed deep engagement, keen interest in the learning content and emotional response (section 9.2.1). These indications are sufficient to assume that there was a strong possibility for attitude change in learners.

The findings of research also pointed to the capability of features which personalised the interactions within the ecoWarrior learning environment to support attitude change. In the Assign Values feature a positive difference in attitude was observed where learners spent a long time with the feature trying to establish which would be the most appropriate choices. This can be attributed to the fact that the Assign Values feature encourages learners to create new meaning in the context of work which is their own and therefore personally relevant.

Finally the ability of narrative to elicit emotional response also needs to be mentioned in relationship to attitude change. Findings pointed to learners engaging in meaningful discussion with the narrative element serving as the subject of discussion (section 9.3; also see Appendix 5, AntiFashionDialogue.mpg). As a result of the discussion, learners' understanding of the subject discussed evolved, suggesting the possibility of attitude change.

Attitude change - Conclusions

Attitude change was established as significant to this research in being a precursor for creativity. An indication that the learning environment is able to elicit attitude change from the learner is an indication that such a learning environment can support creative development. The findings of this research with relation to creativity pointed to evidence of factors and elements within the interactive learning environment which were able to support the development of attitude change in learners. While no definitive evidence was gathered regarding whether attitude change took place, evidence did point to the factors which contributed to learners engaging more deeply with the learning content, learners displaying intrinsic motivation towards their work, and learners emotionally responding to the learning content. These are all indications which, if not definitively indicate, suggest the beginning of attitude change in the learner.

In identifying the elements and factors contributing to such affective change research is in fact contributing to our understanding of how interactive media can support creativity in the learner.

11.3. Original contributions to knowledge

The contributions to knowledge of this research can be seen as filling a gap in the two key fields of research concerned – D&T education and interactive media for learning. The field of computer based learning for creativity has only recently started to evolve, with new journals such as Thinking Skills and Creativity directing their attention to these issues (http://authors.elsevier.com/JournalDetail.html?PubID=706922&Precis=EB). In its turn, a gap exists in Design and Technology education research. Since the All Our Futures report in 1999, D&T research has extensively explored creativity as a learning objective. However, little attention has been given to researching the potential of interactive media as the tool for enhancing creativity in the learner.

Through its interdisciplinary nature, this research manages to give attention to both interactive media and D&T education in the context of creativity. Thus the findings of research and its contribution to knowledge affect both the design of interactive learning environments and creative work on a subject specific level.

The two evaluative studies of this research, the Learning Needs interviews and the ecoWarrior observation sessions, have investigated the value of interactive media to supporting learning and creativity in Design and Technology education. The key findings discussed in the previous section make several original contributions to knowledge discussed below.

11.3.1. Promoting learner autonomy

Within the learning setting the teacher, the learners and the interactive learning environment need to adopt specific roles, which would impact most effectively on promoting learner autonomy and in this way would influence creative development in the learner. This research has defined these roles in relationship to autonomy, as well as providing evidence of the benefit they have to the learner.

Autonomy was established as a key factor for the development of creativity. In the context of this research the term 'autonomy' refers to the relative independence of the learner from the teacher as an authority figure. An interactive learning environment provides opportunities for such autonomy to develop. However such autonomy needs to be appropriately managed in order to benefit the learner. The original contribution to knowledge of this research is in identifying the specific roles which the teacher, learners and the interactive learning environment play in making such autonomy work in terms of both learning and creativity.

The learners' role emerged as the most important constituent part in supporting learner autonomy. Learner-to-learner dialogue was identified as the key to promoting learner autonomy. The learner's role therefore was defined in terms of the attitude which learners would adopt in their discussion – an attitude of helping each other; the feeling of collective ownership of the idea; and an intrinsically motivated attitude to the work.

The teacher's role in promoting learner autonomy was defined in terms of the degree and nature of the teacher's intervention, as well as the timing in which the teacher intervened. This was specifically important at the stages of finding contexts to work within and generating ideas. What is significant to note is that the teacher's role was defined in relationship to the learner's role and that of the learning environment, thus taking a holistic approach to the design of the learning experience.

The role of the learning environment in promoting learner autonomy was defined in terms of the nature of the learning content and the structure of the learning interactions.

The cluster of findings regarding promoting learner autonomy, make a specific contribution to knowledge. The relationship between autonomy and creativity has been firmly established within the literature on education. In this aspect autonomy has been considered as an aspect which needs to be managed by the teacher (Rutland and Barlex, 2002). Other studies have considered the value of computer supported learner-to-learner dialogue (Vass, 2002), however have not considered the role of teacher-to-learner dialogue and the role of the interactive learning environment. Further studies have explored learner autonomy in the context of an interactive learning environment in terms of structuring of the learning content (Boyle, 1997(c)). Yet none of these studies have investigated the roles of all three elements – the teacher, the learner and the interactive learning environment – to promoting learner autonomy. This research takes all three elements into consideration and draws out specific guidelines of how they can be optimally resolved, how they work together and relate to each other, in order to provide an environment which is capable of supporting learner autonomy.

Furthermore, by being descriptive of instances in which teacher intervention has been successful and analysing instances where it has failed to make an impact, this research is able to assert the detailed conditions for productive teacher intervention. Similarly, in analysing learner-to-learner dialogue and collaboration, research was able to point out what made such dialogue productive and identify the factors contributing to this success, considering the roles of teacher, learner and learning environment within this. Finally, evaluating the particular aspects of the learning environment which managed to support learner autonomy most successfully, made implications for the role of interactive media to autonomy and creative learning.

11.3.2. The value of dialogue and collaboration

Within an interactive learning environment, dialogue and collaboration act as a vehicle for learner autonomy and creativity in the context of Design and Technology education.

The findings of research have made explicit that supporting learner autonomy depends on maintaining collaboration and an evolving dialogue between learners. Collaboration and dialogue were therefore identified in this research as the vehicle through which learner autonomy becomes a useful learning and creative tool.

The value of collaboration to learning and creativity was reaffirmed in this research, both through students articulating their own experiences of creativity in the Learning Needs interviews and through the positive outcomes collaboration had within the ecoWarrior evaluative sessions. The findings of research pointed to the ability of collaboration to support seeing things from a different perspective; its ability to support thinking.

However, these findings in themselves could not confidently constitute original contributions to knowledge, since evidence already exists in research literature for the value of dialogue and collaboration to learning and creativity. Such evidence exists in the field of D&T educational research (Hennessy & Murphy, 1999; Hamilton, 2004; Head, Dakers, 2005), and in learning theory (Vygotsky, 1978(b); Lave, Wenger, 1991(a)), the latter of which it needs to be noted does not make a direct relationship to the value of collaborative discussion to creativity. The former however has done so to a certain extent.

In adopting a combination of approaches, conversation analysis alongside grounded theory, this research contributed to our understanding of how dialogue and collaboration contribute to creating the optimal conditions for supporting an attitude of exploration and autonomy in learners. These conditions relate to the role of the teacher, the learners and the learning environment in promoting collaborative dialogue in learners. The true original contribution to knowledge in terms of dialogue and collaboration is in furthering our understanding of why and how dialogue and collaboration work to promote creativity within an interactive learning setting. Answering these questions contributed to knowledge in the following aspects:

- Learners' dialogue made explicit the nature of students' motivation, and within this, how this motivation becomes intrinsic;
- Learners' dialogue helped understand the circumstances in which learners were encouraged to naturally adopt a form of collective ownership, rather than individual ownership. This appears to conflict with existing literature in the field (Jones, Issroff, 2005), where the feeling of ownership is seen as positive to learning. Yet in a learning environment where intrinsic motivation is of the highest importance, a different form of ownership is valued – collective rather than individual;
- Learners' dialogue and the nature of their collaboration helped uncover how a pair of learners naturally adopt roles within a collaborative discussion – one of positing ideas and the other in questioning these, without this resulting in conflict, but rather in refining and improving the design idea they were working on. Within this the conditions of learning were explored in terms of the respective teacher, learners and learning environment's roles;
- The exploration of dialogue further pointed to a relationship between the nature of dialogue and the type of knowledge which it is likely to benefit. Learner to learner dialogue was found to be more productive of original thought while teacher to learner dialogue was more beneficial to

supporting declarative knowledge. This made implications for the respective roles of teacher and learners in dialogue.

11.3.3. The role of the learning environment

An interactive learning environment has two specific characteristics which work to enhance learning and creativity – its flexibility and its capacity to personalise the learning interactions. This research has explored how these characteristics support learner autonomy, creativity as well as contributing to differentiation.

The interactive learning environment was identified as having specific significance and playing a particular role in each of the contributions to knowledge already discussed. Research identified two key characteristics which make digital media unique in their ability to support autonomy and creativity in the D&T learner. These characteristics were flexibility and personalisation.

Flexibility

The flexibility of interactive media has been acknowledged previously in research literature as an advantage in terms of its ability to support learners in creating a cognitive space within the learning content (Bekier, 2005). Yet the relationship of flexibility to creative learning has not previously been established. The value of this research is in uncovering this relationship. Research discussed specific instances in which learners benefited from such flexibility, particularly in becoming more autonomous in their learning interactions (see section autonomy). Further, the findings of research pointed to the ability of various features within the learning environment to support both collaborative and individual approaches to learning. Through these findings research was able to conclude that in generative as well as in reflective thinking, learners always combined individual and collaborative approaches. While the benefits of combining different approaches to learning within the same learning environment has been discussed, particularly in the literature review on learning theory, such discussion has not so far considered the role of an interactive learning environment in contributing to combining approaches. This research was able to establish that an interactive learning environment has a key advantage in supporting varied approaches to learning - through its flexibility it is able to support both individual and collaborative approaches, providing a richer experience to the learner.

The value of flexibility to creative learning can be defined as:

- The non-hierarchical nature of the way content is organised, which allows learners to tailor the learning experience according to their own learning needs and interests – the unique value of interactive media in this respect is that it allows learners to adapt the learning experience according to their own learning needs;

- The unique value of digital media to support both collaborative and individual learning approaches.

Being aware of how the positive effect of flexibility works, makes clear implications for the design of interactive learning content which is able to support creativity in the learner.

One specific aspect in which the flexibility of interactive media emerged as important was the issue of differentiation. Differentiation is known as a complex issue in education and issues such as preserving the learner's self esteem and avoiding grouping learners according to ability are problematic (Dillon, Maguire, 2001). By observing the way in which learners used the interactive learning environment, the flexibility of the medium – allowing for different pathways through content and the possibility to afford a choice in the learning content they are exposed to – offers unique opportunities for implementing differentiation. However, this topic was not thoroughly researched and research cannot claim it has evaluated the effect of the learning environment on differentiation, since this was not the starting point of research and differentiation is an issue which only marginally concerns creativity. The originality of the findings is in establishing a realistic possibility that interactive media can have a very positive impact where differentiation is concerned.

Personalisation

The second key characteristic of interactive media for supporting creative learning was that of personalisation. In the findings of research the ability of learners to personalise the learning content was identified as working on the affective layer of learning – learners responded emotionally to the learning content, precisely because they were able to personalise it and see its direct relevance to their own work. A number of features in the learning environment were identified as contributing to such personalisation.

This ability of digital media to support learners in making the learning content their own, while manipulating it and adapting it to their own needs is valuable to creativity. Where learners are able to explore their own ideas in new contexts without losing sight of the work as personally relevant, creativity is more likely to be supported. Further, as research literature identifies, learning only happens when the cognitive conflict becomes personally relevant (Mercer, 2000(b)). In this context interactive media seems to be successful. The ability of interactive media to provide opportunities for personalising the learning content enhances its potential as a tool for creative learning. This relationship between personalising learning through digital media and its effect on creativity emerges as an original contribution to knowledge.

11.3.4. Attitude change

Interactive learning environments can be designed to support attitude change in the learner. Such attitude change could have a positive impact on learner creativity.

The relationship between attitude change and creativity was established in the literature review as Gagne's idea that attitude change is the learning capability which is closest to supporting creativity (Gagne, 1985(a)). At the same time attitude change is the least explored of the learning capabilities by Gagne and this is where this research has aimed to make a contribution.

The originality of the findings which this research makes regarding attitude change is that collectively they describe instances in interacting with a digital learning environment, where attitude change is facilitated. Specific features in the interactive learning environment are described in terms of how they contribute to such attitude change. In being descriptive of these instances and features research identifies the conditions of learning within an IMLE, which facilitate attitude change, and therefore, indirectly, creativity. These conditions can be used as guidelines for the design of interactive learning, where attitude change and creativity form part of the learning objectives.

11.3.5. The ecoWarrior interactive learning environment

The ecoWarrior interactive learning environment itself stands as an original contribution to knowledge. In its pedagogical design ecoWarrior implements each of the key aspects identified as enhancing learner autonomy and creativity in D&T students. In these terms it provides a unique learning environment, which is a practical example of how interactive media can be used to enhance learning and creativity in D&T education.

Firstly, ecoWarrior provides opportunities for promoting learner autonomy. The design and structure of its learning interactions places an emphasis on students working collaboratively on the development of design ideas. In addition, the teacher's role is defined as a learning facilitator.

Secondly, ecoWarrior implements the principles of flexibility and personalisation, identified in this research as supporting learner autonomy and creativity. It is flexible in allowing learners to tailor their learning interactions according to their specific learning needs. In addition, when using ecoWarrior learners can personalise the learning interactions, by adding and manipulating new content which is personally relevant to them.

Finally, ecoWarrior influences attitude change in learners. By using content which encourages the learner to engage emotionally with the learning content, ecoWarror acts on the affective layer of learning and supports a desired attitude change in the learner, both towards the subject of sustainable design and towards their own design work.

11.3.6. Original contributions to knowledge – summary

To summarise, each of the original contributions to knowledge have significance to enhancing creativity and promoting autonomy in the D&T learner. Following is a concise summary of the specific contributions:

- Within the learning setting the teacher, the learners and the interactive learning environment need to adopt specific roles, which would impact most effectively on promoting learner autonomy and in this way would influence creative development in the learner. This research has defined these roles, as well as providing evidence of the benefit they have to the learner (section 11.3.1).
- Within an interactive learning environment dialogue and collaboration act as a vehicle for learner autonomy and creativity in the context of Design and Technology education (section 11.3.2).
- An interactive learning environment has two specific characteristics which work to enhance learning and creativity – its flexibility and its capacity to personalise the learning interactions. This research has explored how these characteristics support learner autonomy and creativity as well as contributing to differentiation (section 11.3.3).
- Interactive learning environments can be designed to support attitude change in the learner. Such attitude change could have a positive impact on learner creativity (section 11.3.4).
- The ecoWarrior IMLE makes a contribution to knowledge in itself. In implementing each of the identified key factors for enhancing creativity and autonomy in the learner, it provides a unique learning experience. Therefore in itself it is a practical example of how interactive media can be used to enhance learning and creativity in D&T students (section 11.3.5).

11.4. Limitations of the study and suggestions for further research

11.4.1. IT provision

In discussing IT provision in the two participating schools, it needs to be noted that there were some significant differences. In School 2 students had better IT facilities as compared to School1. School 2 had a dedicated computer room for D&T activities, equipped with fast computer processors, flat screens, faster graphics cards and the capability to play sound. In contrast, in School 1 IT facilities were outdated, with slow processors which posed difficulties with handling multimedia content and had no capability to play sound. School 1 also lacked a dedicated computer room for D&T which meant that each session was held in a different classroom depending on availability.

Considering that it was not the subject of investigation, conclusions cannot be drawn regarding the effect of IT facilities in the school on students' learning. However allowance needs to be made for the fact that the IT facilities within the learning environment may affect performance. It seems likely that in School 2 students were more at ease with manipulating interactive learning content than those in School 1 because they had better facilities. As a result it needs to be considered that some of the findings relating to autonomy (section 8.2.2), collaboration (8.3.4), self-directed learning (section 9.4.1) may have been influenced by the quality of IT provision in the school. In particular, some of the most significant findings regarding learner-to-learner dialogue were observed primarily in School 2, with some supportive evidence from School 1. There is a significant possibility that the reason why collaboration worked better in School 2, was that students benefited from a smooth, unproblematic multimedia presentation, enhanced with sound – all of these aspects add to a stimulating learning experience; when taken away they could impact negatively on the learning process.

11.4.2. Researcher intervention

It needs to be considered that my role as a participant observer in the learning interactions may have had an influence on the research. This is particularly relevant to findings concerning the value of a Conversational Framework type dialogue to declarative knowledge (section 10.5.1). This is the sole instance where a specific teaching skill was utilised in questioning the students with open ended questions. However it needs to be said that this does not compromise the value of the findings, since the approach which I adopted can easily be applied by any teacher, on the condition that they were aware that open ended questioning was the best approach to use alongside the interactive learning environment.

This has implications for the further development of the learning environment – in order to be complete, the software needs to be accompanied with supportive guidance learning materials such as a book of lesson plans, which would give suggestions to teachers regarding the optimal approach to use.

11.4.3. Autonomy

The findings of research regarding the teacher's role in supporting learner autonomy have their limitations. While these findings were based on a longitudinal observational study where teachers' intervention could be evaluated in a number of situations, the teachers' own perspective on teaching with an interactive learning aid has not been considered. The research has tried as much as possible to gather any verbal comments in the form of teachers' opinion of the learning and teaching experience, however the strongest data in this respect remains this gathered through observation. This limitation was due to teachers' busy schedules. Even though a user experience questionnaire was distributed to the teachers participating in the evaluative sessions, in most of the cases the questionnaire was not returned.

This limitation opens possibilities for future work, focusing on the teachers' experience of using interactive learning tools to support creative learning in students.

11.4.4. Attitude change

The findings of research regarding attitude change are limited through the difficulty of trying to evaluate anything as subtle as attitude change. While the longitudinal study approach was successful in mapping some change in learners' actions and in their emotional response, it was still difficult to determine whether such change would be long lasting and if it would influence their thinking in the long term.

In a number of cases learners were very stimulated and reacted positively to the learning content. This could be interpreted as learners displaying an affective response to the learning content. However while the findings of research could be taken to indicate a change in the learner's attitude, towards the subject and towards their own work, there is no concrete evidence to indicate that such change has taken place. It is only the precursor of attitude change which is present – emotional response, stimulated learners who are willing to explore further - but not the result.

It would have been possible to observe the result in learners' project work. If in their choice of project work learners would show the effects of studying and exploring the issues of sustainable design, then this could have been taken as an indication of practical attitude change, where what has been learned was also applied in actual project work. The study is limited in this respect. However, due to limitations in time as well as having to observe the scale of the study, further research on students' project work was not plausible. On the other hand, this could realistically be seen as a possibility for future research. A further stage would be added to the evaluation of the learning environment which would involve monitoring the kinds of project ideas students generate in year 13 of their A level studies and evaluating whether these ideas have been influenced by the ecoWarrior learning content.

11.4.5. Methodology

Within the ecoWarrior evaluative sessions the user experience questionnaires were used as a form of methodological triangulation to data which was primarily qualitative, descriptive and observational in nature. However, it was also the only form of data gathered which afforded learners an opportunity to personally express their experience with the learning environment. Judging by the success of the Learning Needs interviews, the focus group approach would have been appropriate in this respect. However due to limitations of access to schools such further research was not viable at the time.

Opportunities for further research in this respect would involve carrying out focus group interviews with learners who have used the learning environment, thus gathering data of students' own experiences of interacting with the learning content. A comparison can be made with data obtained through observation.

11.4.6. Differentiation

While this research did not set out to explore differentiation, it emerged as a form of learning need which was of particular interest. The findings of research pointed to the flexibility of interactive media as a property which could be used to support differentiation in learning. This is a complex issue which needs specific attention and in this respect the findings of this research are limited. The claim cannot be made that the flexibility of digital media alone would be able to support differentiation, yet this research has helped reveal this as a realistic possibility, which furthermore can constitute possibilities for future research.

11.4.7. Generalisability of the study

From the very beginning this research was grounded in the subject area of Design and Technology education. It would be natural therefore to conclude that the findings of research and its contributions would be to knowledge in the D&T education field. However, the literature review took into consideration areas and issues broader than those immediately concerning D&T education – such as creativity in education, the theory of learning, research into collaboration in interactive media and game-based learning. As a result of this, as well as of the findings of the Learning Needs interviews, the focus of investigation for the research became less confined to the subject and purely focused on students' interactions with the interactive learning environment. The focus of the study and in particular the findings of the study concern issues such as autonomy, collaborative work, the role of interactive media and affective response from the point of view of how they relate to creativity. Virtually every single one of these findings can be used as guidelines for how interactive media can be utilised in any subject area which has creativity as part of its learning objectives.

11.5. Developments from the work

In this final section, I identify key outputs from the research which have already taken place.

Conference papers

The findings of research have been presented at three international conferences. Each of these presentations have resulted in publications:

- Ehiyazaryan, E. 2006, "Game-based Learning in Design and Technology - an Evaluation of a Multimedia Learning Environment", *Proceedings of* *the International Design and Technology Association Conference - Designing The Future,* DATA, UK.

- Ehiyazaryan, E. 2005, "A Situated Learning Approach to Enhancing Creativity in the Design and Technology Learner", *Designs on eLearning: the International Conference on Learning and Teaching in Art, Design and Communication, 2005.*

- Ehiyazaryan, E., Williams, N. & Lewis, T. 2004, "Defining User Requirements and Strategies for a Multimedia Learning Environment Aimed at Enhancing Creativity in A level Design and Technology Teaching and Learning", *Creativity and Innovation - DATA International Research Conference*, eds. E. Norman, D. Spendlove, P. Grover & A. Mitchell, DATA, UK, pp. 73.

This has been beneficial in allowing research to leave the immediate setting in which it has been generated and allow for it to benefit from the broader opinions of external research communities. The two broad research communities to which research has been exposed which are also the disciplines where research seeks to make an intervention and contribute to developing, were Design and Technology education and e-learning, with a focus on interactive learning environments in the arts and humanities.

Research seminars

A series of seminars have been given to the following research communities:

Members of staff and fellow research students at Sheffield Hallam University:

- *Structured Learning and Multimedia for Enhancing Learning and Creativity in the Design and Technology Learner* – Seminar presentation with members of staff and colleagues at the Art and Design Research Centre, Sheffield Hallam University, October, 2005

- *Structured Learning and Multimedia for Encouraging Learning and Creativity in D&T Students* - Seminar presentation with members of staff and colleagues at the Art and Design Research Centre, Sheffield Hallam University, 25th May, 2003

D&T teachers participating at the annual Design and Technology Association conference Designing The Future (2006):

- *EcoWarrior – Digital Game-based Learning for Sustainable Design –* seminar given at DATA conference, July 2006

Competition entries

The learning environment was entered for the Innovate to Educate Award, organised by Futurelab (Futurelab - Innovation in Education). The competition entry was entitled:

ecoWarrior – a prototype for an interactive media learning environment which aims to address learning and creativity in Design and Technology education

The entry was short-listed for a secondment with industry.

Curriculum development

ecoWarrior is currently being used as part of the curriculum for a new scheme run by Sheffield Hallam University, aimed at encouraging A level D&T learners to undertake a career in engineering. ecoWarrior is being used as the basis for a module in sustainable design. This is one of the measures being taken towards developing the prototype learning environment into a full application with the possible outcome of being integrated in schools' curricula.

Bibliography

1. Adams, D. 1973, "How Simulation Games Relate to Learning" in *Simulation Games: An Approach to Learning* Wadsworth Publishing Company, Inc., California, pp. 9-29.
2. Barlex, D. 2003, "Considering the impact of Design and Technology on society - the experience of the Young Foresight project", *Pupils' Attitudes towards Technology International Design and Technology Conference (PATT-13)*, eds. J. Dakers & M. Vries.
3. Bekier, G., *Interactivity, Navigation and Learner Control in Educational Multimedia*. Available: http://www.usq.edu.au/course/material/FET8620/resources/2002s2conf/papers/bekier.html [2005, 12/05].
4. Bijleveld, C.C. J. H. 1998, "Methodological issues in longitudinal research" in *Longitudinal data analysis Designs, models and methods*, 1st edn, SAGE Publications, London, pp. 1.
5. Boyle, T. 1997(a), "Structured learning: Guided discovery learning environments" in *Design for multimedia learning* Prentice Hall Europe, pp. 45.
6. Boyle, T. 1997(b), "Strategic approaches to educational multimedia design" in *Design for multimedia learning* Prentice Hall Europe, pp. 67.
7. Boyle, T. 1997(c), "Conceptual Design - Strategic Approaches to Educational Multimedia Design - Constructivism" in *Design for Multimedia Learning*, 1st edn, Prentice Hall Europe, pp. 70.
8. British Educational Communications and Technology Agency (BECTA) 2001, *Computer Games in Education Project*. Available: www.becta.org.uk/research [2005].
9. Bruner, J.S. 1966, ***Studies in cognitive growth: a collaboration at the Center for Cognitive Studies,*** Wiley.
10. Bryman, A. 2004, "Research designs" in *Social Research Methods*, 2nd edn, Oxford University Press.
11. Coffey, A., Holbrook, B. & Atkinson, P. 1996, "Qualitative Data Analysis: Technologies and Representations", *Sociological Research Online,* vol. 1, no. 1.
12. Cohen, L., Manion, L. & Morrison, K. 2000(a), "Interviews" in *Research methods in education*, 5th edn, RoutledgeFalmer, USA, pp. 288.
13. Cohen, L., Manion, L. & Morrison, K. 2000(b), "Reliability, Validity and Triangulation" in *Research Methods in Education*, 5th edn, Routledge/Falmer, London and New York.
14. Cohen, L., Manion, L. & Morrison, K. 2000(c), "Action research" in *Research Methods in Education*, 5th edn, Routledge/Falmer, London and New York, pp. 226.
15. Cohen, L., Manion, L. & Morrison, K. 2000(d), "Naturalistic and Ethnographic Research" in *Research Methods in Education*, 5th edn, Routledge/Falmer, London and New York, pp. 137.

16. Cohen, L., Manion, L. & Morrison, K. 2000(e), "Surveys, Longitudinal, Cross-Sectional and Trend Studies" in *Research Methods in Education*, 5th edn, Routledge/Falmer, London and New York.
17. Cook, J. 2002, "The role of dialogue in computer- based learning and observing learning: an evolutionary approach to theory", *Journal of Interactive Media in Education,* no. 5.
18. Cropley, A.J. 2001, "Creativity: Basic Concepts" in *Creativity in education and learning* Kogan Page Limited.
19. Crotty, M. 1998, "Introduction: The Research Process" in *The foundations of social research : meaning and perspective in the research process*, 1st edn, SAGE Publications Ltd, London, pp. 1-17.
20. Csikszentmihalyi, M. 1996(a), *Creativity - Flow and the Psychology of Discovery and Invention,* 1st edn, HarperCollins Publishers.
21. Csikszentmihalyi, M. 1996(b), "The Flow of Creativity" in *Creativity - Flow and the Psychology of Discovery and Invention*, 1st edn, HarperCollins Publishers, pp. 107.
22. Dillon, J. & Maguire, M. 2001, "Differentiation in Theory and Practice" in *Becoming a Teacher - Issues in Secondary Teaching*, 2nd edn, Open University Press.
23. Dondi, C., Edvinsson, B. & Moretti, M. 2004, "Why Choose a Game for Improving Learning and Teaching Processes" in *Guidelines for Game-Based Learning*, eds. M. Pivec, A. Koubek & C. Dondi, 1st edn, Pabst Science Publishing, Lengerich, Germany, pp. 24.
24. Doolittle, P. & Camp, W. 1999, *Constructivism: The Career and Technical Education Perspective*, http://scholar.lib.vt.edu/ejournals/JVTE/v16n1/doolittle.html edn, Digital Library and Archives.
25. Ehiyazaryan, E. 2005, "A Situated Learning Approach to Enhancing Creativity in the Design and Technology Learner", *Designs on eLearning: the International Conference on Learning and Teaching in Art, Design and Communication, 2005*.
26. Ehiyazaryan, E. 2006, "Game-based Learning in Design and Technology - an Evaluation of a Multimedia Learning Environment", *Proceedings of the International Design and Technology Association Conference - Designing the Future* DATA.
27. Ehiyazaryan, E., Williams, N. & Lewis, T. 2004, "Defining User Requirements and Strategies for a Multimedia Learning Environment Aimed at Enhancing Creativity in A level Design and Technology Teaching and Learning", *Creativity and Innovation - DATA International Research Conference*, eds. E. Norman, D. Spendlove, P. Grover & A. Mitchell, DATA, UK, pp. 73.
28. Gagne, R. 1985(a), "Attitudes" in *The conditions of learning and theory of instruction*, 4th edn, Holt, Rinehart and Winston, New York.
29. Gagne, R. 1985(b), "What is Learned - Varieties" in *The Conditions of Learning and Theory of Instruction*, 4th edn, Holt, Rinehart and Winston, pp. 46.
30. Gagne, R. 1985(c), "Designing instruction for learning" in *The conditions of learning and theory of instruction*, 4th edn, Holt, Rinehart and Winston, New York.
31. Gagne, R.M., Briggs, L.J. & Wager, W. 1988, *Principles of Instructional Design,* 3rd edn, Holt, Rinehart and Winston, inc, USA.

32. Garrett, J. 2003, "The Skeleton Plane - Navigation Design" in *The Elements of User Experience - User-centered Design for the Web* American Institute of Graphic Arts.
33. Gee, J. 2003, "Semiotic Domains: Is Playing Video Games a "Waste of Time"?" in *What computer games have to teach us about learning and literacy* Palgrave Macmillan, pp. 13.
34. Genzuk, M., *A synthesis of ethnographic research*. Available: http://www-rcf.usc.edu/~genzuk/Ethnographic_Research.pdf. [2004].
35. Glaser, B. & Straus, A. 1967(a), "Generating theory" in *the discovery of grounded theory* Aldine publishing company, New York, pp. 21.
36. Glaser, B. & Strauss, A. 1967(b), "The constant comparative method of qualitative analysis" in *the discovery of grounded theory* Aldine Publishing Company, New York, pp. 101.
37. Grant, L. 2005*, Researching Creativity: An Experiential Methodology* [Homepage of Futurelab], [Online]. Available: http://www.futurelab.org.uk/viewpoint/art60.htm [2006, 25/07].
38. Hamilton, J.W. 2004, "Enhancing learning through dialogue and reasoning within collaborative problem solving", *The Design and Technology Association International Research Conference*, eds. E. Norman, D. Spendlove, P. Grover & A. Mitchell, DATA, , pp. 89.
39. Head, G. & Dakers, J. 2005, "Verillion's trio and Wenger's community: learning in technology education", *International Journal of Technology and Design Education,* vol. 15, no. 1, pp. 33-45.
40. Heath, C. & Hindmarsh, J. 2002, "Analysing interaction: Video, ethnography and situated conduct" in *Qualitative Research in Action*, ed. T. May, SAGE, London, pp. 99-121.
41. Hennessey, B.A. & Amabile, T.M. 1988, "The conditions of creativity" in *The nature of creativity*, ed. R.J. Sternberg, Cambridge University Press, United States of America, pp. 11.
42. Hennessy, S. & Murphy, P. 1999, "The potential for collaborative problem solving in Design and Technology", *International Journal of Design and Technology and Design Education,* vol. 9, no. 1, pp. 1-36.
43. Howe, K. & Berv, J. 2000, "Constructing constructivism, epistemological and pedagogical" in *Constructivism in education: opinions and second opinions on controversial issues*, ed. D.C. Phillips, the national society for the study of education, pp. 19.
44. Issroff, K. & del Soldato, T. 1996, "Incorporating motivation into computer-supported collaborative learning", *Proceedings of European conference on artificial intelligence in education,* Ficha Tecnica, Lisbon.
45. Jones, A. & Issroff, K. 2005, "Learning Technologies: Affective and social issue in computer-supported collaborative learning", *Computers & Education,* vol. 44, no. 4, pp. 395-408.
46. Kimbell, R. 2000(a), "Creativity, Risk and the Curriculum", *The Journal of Design and Technology Education,* vol. 5, no. 1.

47. Kimbell, R. 2000(b), "Creativity in Crisis", *The Journal of Design and Technology Education,* vol. 5, no. 3, pp. 206.
48. Kimbell, R., Stables, K., Wheeler, T., Wosmak, A. & Kelly, V. 1990, "The Interaction of Mind and Hand" in *The Assessment of Performance in Design and Technology* SEAC and The Central Office of Information, pp. 19.
49. Kirriemuir, J. & McFarlane, A. 2004, *Literature Review in Games and Learning - a Report for NESTA Futurelab*, NESTA Futurelab, Bristol.
50. Koutsides, G. 2001, "Using cooperative learning in Design and Technology", *The journal of Design and Technology Education,* vol. 6, no. 1, pp. 55.
51. Kuutti, K. 2001, "Activity Theory as a Potential Framework for Human-Computer Interaction Research" in *Context and Consciousness - Activity Theory and Human-Computer Interaction*, ed. B. Nardi, The MIT Press, Cambridge, Massachusetts.
52. Lansdale, M. & Ormerod, T. 1995, "Maintaining dialogues" in *Understanding Interfaces - A Handbook of Human - Computer Dialogue*, 1st edn, Academic Press, San Diego, pp. 113.
53. Laurillard, D. 1998, "Multimedia and the learner's experience of narrative", *Computers & Education,* vol. 31, no. 2, pp. 229.
54. Laurillard, D. 2002(a), "A framework for analysis" in *Rethinking university teaching: a framework for effective use of educational technology*, 2nd edn, London: Routledge, London and New York, pp. 81.
55. Laurillard, D. 2002(b), "Analysing the media for learning and teaching" in *Rethinking university teaching: a framework for effective use of educational technology*, 2nd edn, London: Routledge, London and New York.
56. Laurillard, D. 2002(c), "Generating a teaching strategy" in *Rethinking university teaching* RoutledgeFalmer, New York, pp. 62.
57. Laurillard, D. 2002(d), "Teaching as mediating learning" in *Rethinking university teaching: a framework for effective use of educational technology*, 2nd edn, London: Routledge, London and New York, pp. 11.
58. Laurillard, D. 2002(e), "The complexity of coming to know" in *Rethinking university teaching: a framework for effective use of educational technology*, 2nd edn, London: Routledge, London and New York, pp. 11.
59. Laurillard, D. 2002(f), "What students bring to learning" in *Rethinking University Teaching: A Conversational Framework for The Effective Use of Learning Technologies*, 2nd edn, RoutledgeFalmer, pp. 25.
60. Lave, J. & Wenger, E. 1991(a), ***Situated learning: legitimate peripheral participation / Jean Lave and Etienne Wenger,*** Cambridge University Press.
61. Lave, J. & Wenger, E. 1991(b), "Legitimate Peripheral Participation" in *Situated Learning: Legitimate Peripheral Participation* Cambridge University Press, pp. 27-42.
62. Lave, J. & Wenger, E. 1991(c), "Practice, Person, Social World" in *Situated Learning: Legitimate Peripheral Participation* Cambridge University Press, pp. 45-54.
63. Lave, J. & Wenger, E. 1991(d), "Legitimate Peripheral Participation in Communities of Practice" in *Situated Learning: Legitimate Peripheral Participation* Cambridge University Press, pp. 89-113.

64. Lewis, T., Chapman, C. & Smart, K. 2004, *Design and Technology (D&T) and Citizenship: Changing Attitudes?*, DATA, The Design and Technology Association.
65. Lindgaard, G. 1994, *Usability testing and system evaluation: a guide for designing useful computer systems,* Chapman and Hall.
66. Loveless, A. 2002, *Literature Review In Creativity, New Technologies and Learning*, NESTA Futurelab.
67. Lunn, S., Davidson, M. & Murphy, P. 2004, *Developing an effective pedagogy for creative problem-solving in design and technology*, OU Knowledge Network.
68. MacMillan, K. & Koenig, T. 2004, "The Wow Factor - Preconceptions and Expectations for Data Analysis Software in Qualitative Research", *Social Science Computer Review,* vol. 22, no. 2.
69. Mercer, N. 2000(a), "Persuasion, control and argument" in *Words and Minds*, 1st edn, Routledge, London, pp. 73.
70. Mercer, N. 2000(b), "Language as a tool for thinking" in *Words and Minds*, 1st edn, Routledge, London.
71. Merrill, M.D. 1975, "Learner Control: Beyond Aptitude-Treatment Interactions", *AV Communications Review,* vol. 23.
72. NACCCE / DfEE 1999, ***All our futures: creativity, culture and education / National Advisory Committee on Creative and Cultural Education***, DfEE, UK.
73. Newman, J. 2004, "Narrative and play, Audiences and Players" in *Videogames*, 1st edn, Routledge, USA, pp. 91-98.
74. Norman, E., Spendlove, D., Grover, P. & Mitchell, A. 2004, "Design and Technology: Creativity in Context", *DATA International Research Conference 2004: Creativity and Innovation* DATA, pp. 2.
75. Oxland, K. 2004, "Genre" in *Gameplay and design*, 1st edn, Addison-Wesley, London, pp. 24.
76. Papert, S. 1980(a), "Turtle geometry: a mathematics made for learning" in *Mindstorms: Children, computers and powerful ideas* The Harvester Press Ltd.
77. Papert, S. 1980(b), "Microworlds: Incubators for Knowledge" in *Mindstorms: Children, computers and powerful ideas* The Harvester Press Ltd.
78. Plowman, L., Luckin, R., Laurillard, D. & Stratfold, M. 1999, "Designing multimedia for learning: narrative guidance and narrative construction", *Proceedings of the SIGCHI conference on Human factors in computing systems: the CHI is the limit* ACM Press, New York, USA, pp. 310.
79. Pomerantz, A. & Fehr, B. 1998, "Conversation Analysis: An Approach to the Study of Social Action as Sense Making Practices" in *Discourse as Social Interaction*, ed. van Dijk, T. A., SAGE Publications, London, pp. 64-91.
80. Preece, J., Rogers, Y. & Sharp, H. 2002(a), "An Evaluation Framework" in *Interaction Design* John Wiley & Sons, Inc, pp. 339.
81. Preece, J., Rogers, Y. & Sharp, H. 2002(b), *Interaction design,* John Wiley & Sons, Inc.
82. Preece, J., Rogers, Y. & Sharp, H. 2002(c), "Understanding and conceptualising interaction: Conceptual models" in *Interaction Design - Beyond Human Computer Interaction* John Wiley & Sons, Inc., pp. 39.

83. Prensky, M. 2001, *Digital Game-Based Learning,* McGraw-Hill.
84. Romiszowski, A. 1988, "The theories of instruction and their use in method / media selection" in *The selection and use of instructional media*, 2nd edn, Kogan Page, London, pp. 15-28.
85. Rutland, M. & Barlex, D. 2002, "The relationship between art & design and design & technology in the English National Curriculum with special reference to creativity", *PATT - 12*.
86. Schiffrin, D. 1994, "Conversation Analysis" in *Approaches to Discourse* Blackwell, pp. 232-239.
87. Shneiderman, B. 1998, *Designing the User Interface: Strategies for Effective Human Computer Interaction,* 3rd edn, Addison-Wesley.
88. Spitulnik, M., Bouillion, L. & Rimmel, N. 2003, "Collaborative online environments for lifelong learning: design issues from a situated learning perspective", *International Journal of Educational Policy Research and Practice*.
89. Spolsky, J. 2001, "Those Pesky Usability Tests" in *User Interface Design for Programmers* Apress.
90. Stables, K. 2004, "The Elusive Keys of Imagination and Play: unlocking creativity and innovation in design and technology education", *The Journal of Design and Technology Education,* vol. 9, no. 3.
91. Strijbos, J.W., Martens, R.L. & Jochems, W. M. G. 2004, "Designing for interaction: Six steps to designing computer-supported group-based learning", *Computers & Education,* vol. 42, no. 4, pp. 403-424.
92. Thorsteinsson, G. & Page, T. 2004, "Innovative Design and Technology education in a virtual learning environment", DATA, UK, pp. 185.
93. Underwood, J. & Underwood, G. 1999, "Task effects on co-operative and collaborative learning with computers" in *Learning with Computers*, eds. K. Littleton & P. Light, Routledge.
94. Vass, E. 2002, "Friendship and collaborative creative writing in the primary classroom", *Journal of Computer Assisted Learning,* vol. 18, no. 1, pp. 102-110.
95. Vygotsky, L.S. 1978(a), "Tool and Symbol in Child Development" in ***Mind in society: the development of higher psychological processes***, ed. M. Cole, Harvard University Press, US.
96. Vygotsky, L.S. 1978(b), "Interaction Between Learning and Development" in ***Mind in society: the development of higher psychological processes***, ed. M. Cole, Harvard University Press, US.
97. Weisberg, R.W. 1988, "Problem solving and creativity" in *The nature of creativity*, ed. R.J. Sternberg, Cambridge University Press, United States of America, pp. 148
98. Welch, M., Barlex, D. & Lim, H.S. 2003, *Sketching: Friend or Foe to the Novice Designer*.

Web site references

1. BBC - Schools, Learning Resources for Home and School, http://www.bbc.co.uk/schools/
2. Curriculum Online, http://www.curriculumonline.gov.uk
3. Futurelab - Innovation in Education, http://www.futurelab.org.uk
4. Futurelab Web Articles, "Researching Creativity: An Experiential Methodology, 2005". http://www.futurelab.org.uk/resources/publications_reports_articles/web_articles?filteryear=2005
5. Nuffield QCA Creativity Research Project, http://www.primarydandt.org/news/nuffield-qca-creativity-research-project,198,NS.html
6. Practical Action – Education, http://www.practicalaction.org/?id=education
7. Practical Action – Sustainable Technology Education Project (STEP), http://www.practicalaction.org/?id=step
8. South Yorkshire e-Learning Programme, http://www.e-sy.info
9. Sustainable Design Award Online, http://www.sda-uk.org/
10. TEP – Technology Enhancement Programme, http://www.tep.org.uk/
11. Young Foresight, http://www.youngforesight.org/yf/www/default.asp

Glossary

Intellectual skills

'Learning an intellectual skill means learning *how to do* something of an intellectual sort. Generally, what is learned is called *procedural knowledge*...Learning how to identify a sonnet by its rhyme pattern is an intellectual skill.' (Gagne, Briggs, Wager, 1988 : 44)

Situated learning

'to be situated knowledge needs to be used in authentic activity, a genuine application of the knowledge. This activity is only authentic if it is embedded in the social and physical world. 'We have to help students not only perform the procedure but also to stand back from it and see why it is necessary, where it fits and does not fit, distinguish situations where it is needed from where it is not, i.e. carry out the authentic activities of the subject expert'

(Laurillard, 2002 : 15)

Knowing what the concept of 'biodegradable' means is not sufficient. Understanding why is the concept necessary and how it finds its application in peoples' lives is necessary. This understanding is at the heart of situating learning.

Cognitive strategies

Involve the learner in being able to set goals, estimate their success (evaluate), select alternative strategies to meet the goals. Cognitive strategies target the learner's own cognitive processes. As a goal cognitive strategies can be expressed as 'teaching students how to think' (Gagne, 1988). The conditions of learning / instruction can only have an indirect effect on developing cognitive strategies. To learn to think, we have to provide opportunities for the learner to think. The performance of cognitive strategies cannot be observed directly, they must be inferred from the performance of other intellectual skills.

Verbal information

Necessary to make communication possible and to encourage citizenship. The performance capability it implies is declarative / factual knowledge - being able to state the facts learned. (p.77). It is the vehicle for thought and problem solving. '...learning that something exists or has certain properties.' (Gagne, Briggs, Wager, 1988 : 44)

Content analysis

'Coding or categorising written or spoken information into a set of descriptive categories. Content analysis reduces verbatim data records into a manageable and quantitative form for more precise description or for testing specific hypotheses... The whole idea of content analysis is to examine how much attention is being paid to an idea or topic of concern by counting the number of occurrences of certain words phrases, events, actions and/or objects.'

(Lindgaard, 1994:119)

Concurrent protocol analysis

'A protocol is a verbal account given by the people who perform tasks. This method requires people whose task performance is to be analysed to 'think aloud' whilst completing the relevant task or set of tasks... users (who may be task experts or novices) are asked spontaneously to verbalise thoughts, ideas facts, plans, beliefs, expectations, doubts and so forth that come to mind during the observation period. Protocols may be concurrent or retrospective. In a concurrent report, the person talks whilst doing, trying to tell the observer what they are doing or going to do, why, what response they expect from the system and so forth.'

(Lindgaard, 1994 : 113)

List of Appendices

All appendices can be found on the DVD attached at the back of the thesis.

Appendix 1

Learning Needs interview, School 1; see LNSchool1.ppt

Appendix 2

Learning Needs interview, School 2; see LNSchool2.ppt

Appendix 3

Learning Needs interview, School 3; see LNSchool3.ppt

Appendix 4

ecoWarrior – an interactive media learning environment; Working prototype; see ecoWarrior.exe

Appendix 5

ecoWarrior evaluation; Video observation

Appendix 6

ecoWarrior user manual; see UserManual.pdf

Appendix 7

User experience questionnaire; see Questionnaire.doc

List of figures