Managing uncertainty and promoting ownership over learning in D&T students using an interactive learning environment

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Abstract

This paper reports on a research study exploring the value of interactive media to enhancing creativity in Design and Technology (D&T) students. The literature review contextualises the issues of self-management and risk-taking as phenomena which need to be managed and supported to ensure successful learning in D&T students. These phenomena are discussed from the point of view of both approaches to designing interactive media for learning and in the context of D&T education.

An action research approach was adopted to exploring the value of interactive media in this respect. The findings of a preliminary study based on focus group interviews carried out with D&T A Level students are discussed, setting out a series of learning needs. These learning needs were derived from students' descriptions of the issues influencing their engagement with creative work. The identified students' learning needs were used to inform the design of an interactive learning environment, including the focus of its content on ecodesign issues, its social constructivist pedagogy and the structure of the learning interactions.

This paper reports on the findings of the evaluation of the interactive learning environment which made implications for the value of interactive media to managing uncertainty and risk-taking in students. The new research findings highlighted the value of interactive media to encouraging students to engage in exploring a design context in an environment free of authoritarian control. The phenomenon of shared ownership over the learning problem emerged as a positive aspect of peer-to-peer collaboration. Finally, the role of the tutor as a facilitator of learning providing scaffolded support to the learning interactions was emphasised.

Key words

managing uncertainty, ownership, creativity, collaborative work, interactive media, Design and Technology

Research context

Interactive media is rapidly becoming an indelible part of school curricula at all levels. This paper explores its value to enhancing learning in Design and Technology (D&T) education, particularly in the context of creativity. Research in this area has identified the key advantages of using interactive media in terms of improving student engagement through the stimuli and opportunities for collaborative learning which it affords (Underwood and Underwood, 1999). Research studies have further pointed to the nature of interactive media learning environments as non-authoritarian (Becta, 2005; Adams, 1973), where risk-taking is supported rather than penalised.

A number of pedagogical models have been explored for structuring content and learning interactions within interactive media learning environments. Boyle (1997) describes the key characteristics and advantages of these different models, ranging from the instructional design perspective based on behaviourist models of education (Gagne, 1985) to constructivist and exploratory approaches to designing interactive media, originating form the social constructivist perspective grounded in the writings of Vygotsky (1978) and adapted for interactive media by Papert (1980). More recent studies of using the constructivist model for the design of interactive media describe their advantages to creative learning (Vass, 2002) and to supporting the development of autonomy in the learner (Laurillard, 2002). Boyle maintains that interactive media learning environments based on the constructivist paradigm place a responsibility on the learner to operate in an autonomous and self-directed way (Boyle, 1997) which could potentially enhance opportunities for divergent thinking and exploratory play and would support the development of self-management and self-esteem.

The issue of supporting the learner in developing autonomy is pertinent particularly in the context of A Level studies, since it is at this stage that the demands on the learner to self-govern their work and to demonstrate original thought become even more pronounced. It is natural therefore that at this stage the D&T student can experience uncertainty and therefore the need for support in preparing students for self-management becomes clear. Research literature in D&T education acknowledges this need and further sees it as a key factor to enhancing creativity in students. In the Nuffield QCA project, Rutland and Barlex discuss the need for managing uncertainty as one of four features for enhancing creativity in the learner, alongside knowledge and skills, reflection, stimulus and a context to which students can relate (Rutland and Barlex, 2002). The authors place 'managing uncertainty' at the centre of these features. This relates to the broader literature on creativity, which emphasises the risky nature of any creative undertaking (Cropley, 2001; Kimbell,

Managing uncertainty and promoting ownership over learning in D&T students using an interactive learning environment

2000; Csziksentmihalyi, 1996). In his article 'Creativity, Risk and the Curriculum', Kimbell (2000) 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 can result in failure before reaching what is a rare, successful and creative outcome. One of the issues this poses is the difficulty which such necessary failure generates with assessment. This results in learners often playing it safe and aiming towards guaranteed success rather than towards a creative design solution. 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: 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: 4)

This leads us to consider that creativity requires a form of non-authoritarian learning environment, within which learners act free from fear of failure and disapproval from an authority figure. In this respect it is necessary to consider whether and to what extent an interactive media learning environment can contribute to supporting students in managing uncertainty, particularly in the context of creative work which entails some degree of risk-taking.

A number of studies focused on the educational potential of interactive media have explored different approaches to scaffolding support for learners in a way which would help them manage uncertainty and exercise autonomous behaviour (Jones and Issroff, 2005; Vass, 2002; Plowman et al, 1999; Laurillard, 1998; Issroff and del Soldato, 1996). One interesting example is Laurillard's research on the MENO project: Multimedia Education and Narrative

Organisation (1998). The MENO project explores the optimum approaches to structuring tasks and narrative content in a way which would support the learner in operating autonomously. Laurillard identifies a framework for the design of narrative into interactive media learning environments which includes:

• Making the narrative explicit as a series of sub-goals
• Active learning through exploration
• Closure on the task which ensures learners know if they have achieved what was intended

(Laurillard, 1998)

Laurillard's framework references the active learning approach characteristic of the constructivist paradigm (Doolittle and Camp, 1999; Boyle, 1997). In highlighting the need for 'closure on the task', Laurillard recommends this to be done through expert feedback, preferably by an expert or teacher. However, being reliant on the external level of support which an expert or teacher would provide poses an issue. On the one hand expert feedback deals with the issue of uncertainty and reduces the risk taken in the work, which as was already discussed are key factors in creative development. On the other hand the question of preserving learner autonomy in a creative task stands: would the learner be able to personalise the content studied and to experience ownership over this content if ultimately the answers of learning and the closure on the task are mediated externally, through a teacher or through 'expert' opinion? This points to the need for a different solution, one which would allow learners to develop ownership over the learning problem as a way of ensuring they will be engaged and fully involved in their creative project work. Rather than relying on expert feedback, this research places an emphasis on the need to explore other forms of support which would allow for the students' voice to predominate in decision-making. One such form of support is collaborative work.

D&T education in particular favours collaborative work as an approach to creative problem solving and this has been used within D&T classrooms extensively. Recent research by Hamilton emphasises the value of collaborative, student-led inquiry particularly to developing playful and imaginative activity in the D&T classroom (Hamilton, 2007). In earlier work Hamilton emphasises the need for the teacher's intervention in pupils' collaborative discussion to be *'sensitive intervention and careful scaffolding of student thinking'* (Hamilton, 2004: 92). This emphasis on the teacher's intervention to be *'sensitive'* and *'careful'* alerts us to the need to consider where and at what point such external intervention is introduced in the creative thinking process in a way which would allow

Managing uncertainty and promoting ownership over learning in D&T students using an interactive learning environment

students to develop skills of self-management and preserve the experience of autonomy for the learner. Reflecting this notion, Hamilton's work shifts the focus from teacher-to-learner to learner-to-learner interactions as the central activity in creative thinking.

Similarly and from the point of view of the situated learning approach as described by Lave and Wenger (1991(a)), Head and Dakers posit the idea of learning in D&T as socially situated collaboration:

'Working together towards a single collective goal rather than individual projects encourages debate and recognition of particular individual skills.'
(Head and Dakers, 2005: 37)

The authors place an emphasis on the creation of communities of practice rather than on individualism in the creative learning process. This point of view once again problematises how within a collaborative learning situation students would have to negotiate ownership over the learning problem, particularly where ideas have been developed in a collaborative way. This research is interested in exploring how such shared ownership over a learning problem in design would influence students' engagement with the project and whether this would impact positively or negatively on their creativity.

Hennessey and Murphy point to the significance of discourse to the development of design ideas and in this way directly reference the positive impact on creativity:

'…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.'
(Hennessey and Murphy, 1999: 2)

It is clear that collaborative work and creative thinking in D&T have strong and empirically proven bonds. The studies discussed above further problematise the issue of how students experience and negotiate ownership of the learning problem once it becomes a collaborative endeavour.

Each of the examples of the value of collaborative learning to D&T discussed above is grounded in the social constructivist paradigm. Lave and Wenger's situated learning approach further draws on social constructivism, yet in addition places a focus on the evolving teacher to learner relationship. From this point of view, learning is

seen not as a single act of internalisation but as *'trajectories of participation'* (Lave and Wenger, 1991(b): 89). Progress in learning is evaluated with the changing roles, which the individual acquires within the learning process and therefore the teacher-learner relationship can no longer be seen as static. The situated learning approach is more than relevant in a D&T school setting, where particularly in the context of creativity, self-directed learning is encouraged and 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 changing emphasis in the roles of teacher and learner and the increased focus on self-directed learning open possibilities for computer-based learning. As was already discussed, 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 as a support mechanism.

The contextual review has already pointed to some of the possible advantages of interactive media both to collaborative work and to students' ability to work autonomously, manage uncertainty and develop self esteem. With regards to the central issue to this research – this of managing uncertainty, research into the affective factors in human computer interactions explores the need for ownership of the learning problem. 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 also seen as a highly motivating factor (Jones and Issroff, 2005: 405). This is also supported by Laurillard who emphasises 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).The question for research is how and to what extent could interactive media play a role in the way students experience and negotiate ownership of the learning problem as well as whether the tools of interactive media can make a positive intervention in this area through supporting the learner in managing uncertainty.

Managing uncertainty and promoting ownership over learning in D&T students using an interactive learning environment

Methodology

An action research methodology was adopted within this research. The first step of data gathering involved exploring students' perspectives on learning in an autonomous and self-managed way at A level. A set of three semi-structured focus group interviews were carried out with D&T A Level students, in three different schools. A total of 17 students participated in the interviews. The purpose of these interviews was to identify some of the issues which learners come across when engaging in a self-directed project in D&T, where there is an expectation for their work to be creative and a need for them to manage this process in a largely autonomous way. Since the interviews primarily concerned students' experiences and perspectives of learning at A level, a semi-structured approach was adopted to interviewing in which learners' discussions were allowed to shape the direction of the interview (Vaughn et al, 1996).

The data which the focus group interviews yielded was used to identify students' learning needs in managing the creative learning process autonomously. These insights into students' learning needs became the basis for the development of an interactive learning environment, entitled ecoWarrior (Ehiyazaryan, 2007). The prototype learning environment was designed to meet the learning needs of the D&T A level student as identified by them. Students would benefit from learning with ecoWarior 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;
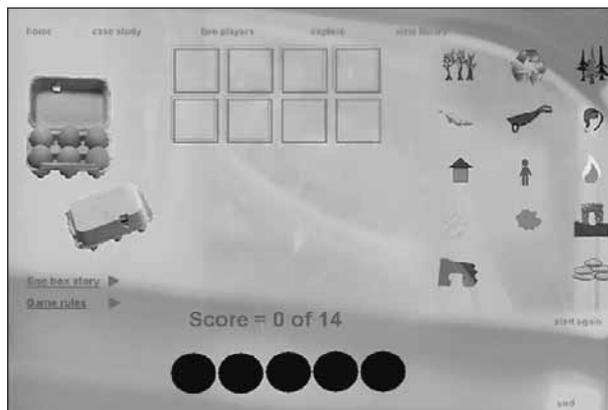
Figure 1: An example of the Case Study module: students learn the relationship be relationship between sustainable design and a given product.

• Engage in practical, hands on sketching tasks which will help them record and develop their thinking.

The interactive learning environment involves three distinct modules working on different levels. The 'Case study' module aims to introduce learners to basic concepts in sustainable design, for example: durability, non-toxic materials, locally sourced materials, recycling, waste. It does this by placing the concepts in the context of an existing manufactured product (Figure 1). The learner's task is to think about how the concepts in ecodesign relate to the product being analysed.
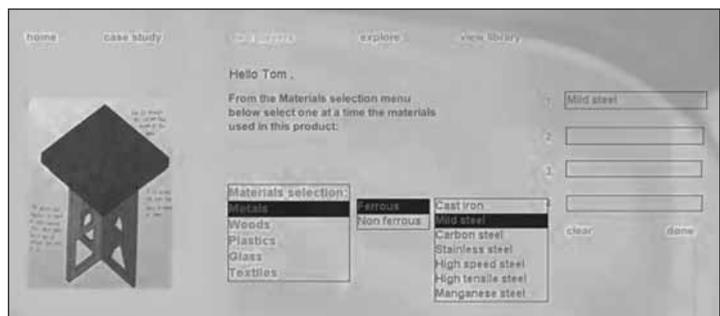
Figure 2 The Two Players Game module: students evaluate how sustainable their own design ideas are.

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 ecodesign, 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 (Figure 2). The most significant difference from the 'Case study' module is that learners are not given any ready-made answers. Instead they have to make informed judgements on how sustainable their own design ideas are.

The Explore module offers a further exploration of the concepts in ecodesign, which students have been working with in the 'Case Study' and the 'Two Players Game' module. The 'Explore' module places an abstract concept, such as 'composting', in the context of broader issues. It stimulates thinking about 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?' It is expected that having thought about real world issues of sustainable design students would then find it easier to respond creatively to these issues.

Managing uncertainty and promoting ownership over learning in D&T students using an interactive learning environment

Figure 3: The Explore module: Students consider the social and ethical implications of sustainable design and respond with design ideas.

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

The interactive learning environment's pedagogic effectiveness and pedagogic responsiveness were evaluated through observation of its use in two different schools. A total of 14 students were observed (5 in school 1 and 9 in school 2) over a period of 4 lessons held in each school. In both cases the sample constituted the entire A2 Level group for D&T in the school. Students were asked to use the learning environment in pairs, to establish a context to work within as well as to respond to this context with collaboratively developed design ideas. The researcher acted as a participant observant, as the main purpose of this action research was to create a positive intervention in classroom learning and teaching practices (Preece et al, 2002). The main focus of observation was the kinds of interactions which developed between students and the types of dialogue which evolved.

Data analysis

The qualitative data which the focus group interviews yielded was analysed, using the grounded theory approach and the constant comparative method as described by Glaser and Strauss (1967, a, b). Coding procedures were followed starting from open coding and proceeding through axial and selective coding, as described by Strauss and Corbin (1998). The grounded theory approach was used as it allowed for the findings of

research in the form of students' learning needs to be grounded in students' perspectives and experiences. As a result the ecoWarrior learning environment was designed to work according to students' self-expressed learning needs.

Analysis of the observation data gathered in evaluating the eoWarrior learning environment drew once again on the grounded theory approach in analysing students' comments while using the learning environment. Alongside this however, research was interested in the way students negotiated meaning when discussing and developing ideas collaboratively. A conversation analysis approach was used (Schiffrin, 1994; Pomerantz and Fehr, 1998) as a way of understanding students' motivation in speaking. In particular Mercer's classification of talk into distinct categories was applied. Mercer identifies three main types of talk which represent the different ways in which people construct an argument: cumulative, exploratory and disputational (Mercer, 2000: 97). By using these types of talk as a guideline, research aimed to understand how learners negotiated meaning and the extent to which their conversation had potential to develop into an original idea.

The action research methodology allowed research to develop a learning environment which was based on students' learning needs as expressed by them, while students' direct use of the learning environment allowed research to draw some important conclusions regarding the value of interactive media to enhancing autonomy and creativity through providing a different level of support to this already existing within the D&T classroom. The following section discusses some of the key findings of this research.

Findings and discussion

Interview data

The data from the focus group interviews set out the issue of ownership as central to students' choice of project at A Level. Within the focus group interviews, A Level students' comments indicated a certain lack of confidence in taking a project into their own hands. In many cases students relied on their teacher to suggest lines of enquiry which could eventually lead to design projects. Students'

comments pointed to the reasons for their reluctance. The following comment illustrates this point:

Researcher: Which stage would you say is the hardest?
Student 2: 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.

Agreement on the difficulty of identifying a worthwhile project at A Level was shared by students across all three focus group interviews. As the student's comment indicates, the main difficulty was this of identifying a design context combined with the feeling of being alone within this process: *'we are totally on our own'.* It is natural that in feeling uncertainty students would seek reassurance and as much support as possible from the teacher in this process. A certain lack of confidence is evident where autonomy is required of the student.

The interviews yielded further data describing the effects of such feelings of uncertainty about self-directed work and being alone in the process of choosing a topic of research for their project. The following comment illustrates some of these effects:

Researcher: Is anyone doing something that resolves a need, improves people's lives?
Student 13: 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?
Student 13: Mr X (teacher) suggested it to me.
Researcher: Do you like the idea of doing something to do with eco design?
Student 13: It's quite interesting - it's resolving a problem that's affecting people.
Researcher: Anyone else?
Student 13: 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?
Student 13: Yes a little bit.

The interview data highlighted that most of the project ideas which the students interviewed chose to pursue,

particularly those which had merit in tackling issues outside of the student's immediate, personal experiences, were suggested by the teacher. To some extent the fact that the area of exploration was suggested by the teacher could mean that the student had less opportunity to experience being an equal partner in deciding on a design brief and was more likely fulfilling a brief assigned by the tutor. In these terms the learner's ability to exercise autonomy could be limited. It is possible that as a result it is less likely for the learner to feel ownership over the learning problem once it has been developed into a design project. Further evidence from the focus groups supported this hypothesis. Students shared instances of having to abandon some of their ideas as less viable or less well considered. The following is one such example:

Student 3: 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 the student's description it appears that he gave up the idea or was discouraged as the idea *'hasn't been accepted'.* Whether the issue was that the student's idea did not fit the boundaries of school work or what would be seen as a successful project, the result of this was that the student had less opportunity to explore, experiment and take on the risk of a less conventional but potentially creative project. More than this, by the student's account, it appears that the student had researched the topic and was genuinely interested in it. In itself such personal interest creates opportunities for ownership of the learning problem, such as significantly contribute to enhancing creativity in exploring this learning problem.

Based on these findings the interview data set out the challenge for the interactive media learning environment to provide students with opportunities to identify appropriate contexts to work within in a self-directed way, while at the same time scaffolding support in this process in a way which would allow students to deal with feelings of being alone in the process or experiencing uncertainty. In addition the need to consider the learning environment, in terms of the nature of the teacher's intervention in the processes of identifying design contexts and generating ideas, became clear.

Managing uncertainty and promoting ownership over learning in D&T students using an interactive learning environment

Taking these learning needs into consideration, the learning environment ecoWarrior was designed to provide interactive content, which was open ended, offering opportunities for learners to firstly choose the context they could focus on and secondly to work collaboratively on this context. Three forms of support were made available to the learner:

- the learning environment provided contextual support and open ended tasks which students could choose to use as a starting point for idea generation;
- the collaborative set up of students working in pairs provided peer support for students as a way of dealing with the uncertainty of creative work;
- the teacher's intervention was expressed in asking students to explain their ideas once they had had sufficient time to discuss these in peer supported groups.

The kind of environment which ecoWarrior provided to students was non-authoritarian, where students could develop ideas collaboratively. In these terms, the environment aimed to place control back into the hands of students, in order to explore whether within such a setup students would feel differently about their design ideas, and if ownership would develop more fully.

Observation data

The observation data as well as students' conversations in using the ecoWarrior learning environment highlighted a number of instances in both of the participating schools where students had engaged in idea generation and development, using the learning content and relying on their collaborative discussion to progress their ideas further. The following example is a discussion between two learners who worked collaboratively to develop a design idea for a compost bin:

Student 6: This is your 'power' idea and I said you have to have an Archimedes screw in it.
Student 7: Ok, well – how about (starts drawing) we've got…I'm trying to think how we could…
Student 6: You can have a screw idea.
Student 7: Yes, I think that's something that would work.
Student 6: You only have to think about how it's going to be powered.
Student 7: You just turn it by hand.
Student 6: Where is the air coming through? The only thing is the compost in fact should be heated from the outside.
Student 7: 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)

Student 6: How do you get it out though?
Student 7: 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…
Student 6: And is the box here though, so it only allows a certain amount in, so if it's filled you can't…
Student 7: What we were to say is that every time you do a load, you just put a load in…
Student 6: Yes.
Student 7: 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.
Student 6: Yes
Student 7: And then next time you put the next load in, turn the handle, and you've got the next level.
Student 6: You could have a bit of storage cause…
Student 7: 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.

It is interesting to observe that both students contributed equally to the development of the compost bin idea, even though the idea initially belonged to Student 7. This provides some indication of how students felt about ownership of the idea. Students contributed equally, adopting shared ownership of the idea. When subsequently asked to describe the solution to their teacher they referred to it as 'our' idea. This is significant since as the contextual review made clear, ownership is seen as a positive, highly motivating affective factor in learning (Jones and Issroff, 2005), predisposing the learner towards discovering individual meaning in their learning as well as being able to more fully situate the subject studied in the context of their own learning (Laurillard, 2002).

In addition, the issue of the nature of these learners' motivation needs to be considered. Hennesssey and Amabile describe intrinsic motivation as one of the factors for enhancing creative thought (1988). The analysis of these students' conversation provided evidence of their intrinsic motivation. Firstly, the type of talk which the two students engaged in was for the largest part exploratory which Mercer describes as the most likely type of conversation to lead to creative thinking and problem solving (Mercer, 2000). Secondly, there was no evidence of competitiveness between the students or of a predominating disputational element in their conversation, which Mercer describes as *'a defensive, uncooperative encounter in which the perspectives of the two*

Managing uncertainty and promoting ownership over learning in D&T students using an interactive learning environment

participants compete with rather than complement each other.' (Mercer, 2000: 97). Finally, students started and finished the conversation with cumulative exchanges, which suggests that the purpose of the dialogue towards the beginning was to be able to improve the idea collaboratively and the purpose of the conversation towards the end was to establish common ground, and to agree on their thinking.

Considering the positive impact of students' collaborative work on their ability to adopt a positive attitude to the work, experience ownership and exercise their creativity, it is necessary to explore the role which the interactive learning environment played and the way it contributed to the positive result.

In light of the data which the focus group interviews yielded, the learning interactions within the ecoWarrior learning environment were designed in a way which allowed learners to generate their own ideas without the help of the teacher. Within this, students relied on the content of the interactive learning environment. In this respect ecoWarrior introduced the broad 'design problem' of composting to students and a task was set encouraging students to come up with a solution. The key difference in the nature of structured support which the multimedia learning environment provided was that students were given the freedom to come up with their own solutions and only enough direction to stimulate and engage them in the design problem. In these terms it can be argued that the non-authoritarian nature of the learning environment made it possible for students to draw on their own resources and develop ideas autonomously.

The role of the teacher was primarily to ask students to explain their idea, once collaborative discussion had taken place between the students. Allowing students time to explore and discuss the idea autonomously meant that they were confident in presenting a well considered idea to the teacher. In this way students were able to retain ownership of the design idea throughout the learning interactions, with minimal but necessary and timely intervention by the tutor. This makes it necessary to consider that the introduction of an interactive learning tool to the classroom makes implications for the development and redefinition of the roles of both teacher and students.

Undoubtedly, the key factor which contributed to students' ability to come up with an original solution, to be confident in presenting it to the teacher and to feel ownership of this solution, was the collaborative element in the learning interactions. It is evident from students' conversation that the idea was able to develop to the level of detail it did because of the interaction of these two students' thoughts with each other. As discussed in the literature review, this phenomenon of the value of collaboration to enhancing creativity is supported by research literature in the field of creativity but particularly in the field of D&T education (Hamilton, 2007; Head and Dakers, 2005; Vass, 2002; Hennessey and Murphy, 1999). The new evidence in this research contributes to this discussion by highlighting that part of the process of enhancing creativity through collaboration is to ensure learners develop ownership of the learning problem. It is the interactive, non-authoritarian learning environment, the role of the teacher and the collaborative discussion between students which in a combined way provided opportunities for students to develop such ownership.

Conclusions

The findings of this research make implications for both the areas of D&T education and for the effective use of interactive media for learning. The need to support risk-taking and manage uncertainty has been an integral part of the creativity discourse in D&T. Within this, the roles of learner, teacher and interactive learning environment need to be reconsidered.

As this research has exemplified, the students interviewed felt essentially alone in the process of taking risks and making autonomous decisions in their work. While the need for support and guidance is clear in this context, this research has also shown that untimely intervention from the teacher could inhibit students' creative exploration and prevent them from experiencing ownership over the learning problem.

The value of peer collaboration, not as a substitute, but as an essential supplement for support from the teacher, emerged as a key factor in supporting learners in developing confidence and ownership over their work. The peer interactions observed as part of evaluating the ecoWarrior learning environment were characterised by students' perception of the design idea they were working on as a common goal, with which came their experience of shared ownership. Having such shared ownership gave these students more confidence in the value of their idea, as both the meaning and the conception of the idea developed as shared understanding. The examples which this research has given of students' ability to manage the uncertainty which is present when students work on design contexts individually, makes a strong case for considering that the shared ownership which students develop through collaboration and peer support is a positive intervention in enabling students to take creative risks in their work.

Managing uncertainty and promoting ownership over learning in D&T students using an interactive learning environment

From the point of view of developing autonomy and the experience of ownership, the value of interactive media as scaffolding support for the learner is evident. The evidence which both of the research experiments yielded, gave significant indication that the way in which these students developed ideas within learner-driven, non-authoritarian interactions had a positive effect on students' ability to take ownership of the learning problem. This makes implications for a positive attitude change in these learners, both towards their work and in their self-esteem and confidence regarding the work.

The essential quality of interactive media in this respect, was its non-authoritarian nature, where interactive, engaging content can be made available to learners and provide guidance in using this content, while at the same time remaining unobtrusive at the stage of decision-making. The strength of interactive media is therefore constructed on the level of stimulus and engagement for students, while leaving the activities of decision-making, exploratory thinking and formative feedback to peer-to-peer interactions. In this sense, this research sees the value of interactive media as a support mechanism to peer-to-peer collaborative interactions, which have proven advantages where creativity is concerned. In reality, the true value of the interactive media learning environment proved to be in facilitating the support necessary for the thinking and collaboration which happened away from the screen.

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