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Motivating children to learn: the role of technology education

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Abstract Design and technology education provides children with opportunities to create solutions to specific needs in innovative ways. This paper reports on research that focused on the language that the children used when they were involved in a design and technology activity. In accessing the results of the language study, the findings suggest that the children's motivation was high and played a significant role in children's task engagement and persistence. Analysis revealed that there were several key ideas that the children focused on, namely: the fun experienced by participating in the activity, the difficulty of doing the task, the satisfaction of completing the task, the importance of social interaction and the frustrations surrounding aspects of the task. These affective factors that are related directly to motivation will be demonstrated through the children's language responses to their participation in design and technology education.

Keywords Motivation Affective factors Language Learning Creativity

Introduction

Teachers often comment on how children find hands-on tasks very satisfying. As indicated by Worth (2009) a quality instructional approach will incorporate well-planned hands-on activities as part of a well-engineered program. Students learn to rely on their own evidence and judgments. They are forced to interpret the observed events and realize that multiple interpretations are sometimes possible. Undertaking their own developmental task allows children to question theirs and others' ideas and provides autonomy over their learning. In fact, the research on experiential learning details how children are strongly engaged with applied tasks and that deeper learning occurs through a 'minds on' aspect of

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the learning experience. This aspect is an important feature of any technology task—that owing to the involvement in the technological process through thinking and doing, children are learning at a much deeper level, both creatively and analytically. Previously we reported on a research project that investigated how the length of the non-thinking incubation period influenced primary school children's creative and analytical thinking associated with a technological activity (Campbell et al. 2004; Jane and Campbell 2006; Webster et al. 2006). Unfortunately, to date, there have been few research studies that have investigated learning in technology from the perspective of children. In this paper we focus on children's views by analyzing their written responses as they engaged in the technological process of designing, making and evaluating recycling devices. We will use the analysis of children's writing to answer the question ''What is the role of motivation and what is its capacity to influence and engage children in the technology task?

The creative process in design and technology education

In the development of technological understanding, Fleer and Jane (2004, pp. 13–14) argue for a holistic approach rather than teaching ''technological skills defined independently of the social and environmental context''. Kimbell, et al. (1996) recognize that the concrete nature of Design and Technology can be a transformative experience, particularly for difficult and disenchanted pupils. Rogoff (1990) emphasises the social and interpersonal nature of the creative process in her view of development as occurring when individualswho-are-participants in ongoing social activity transform themselves-and-activity into a new form through active, constructive appropriation. ''Psychologist Mihaly Csikszentmihalyi (1996) claims that the term 'creative' originally meant ''to bring into existence something genuinely new that is valued enough to be added to culture'' (cited in Gardner 2001, p. 117). To describe something as creative requires social confirmation by the appropriate experts.

> Creativity, the kind that changes some aspect of the culture, is never only in the mind of a person. That would, by definition, not be the case of cultural creativity. To have any effect, the idea must be couched in terms that are understandable to others, it must pass the muster with the experts in the field, and finally it must be included in the cultural domain to which it belongs. (Csikszentmihalyi cited in Andreasen 2006, p. 15).

The generative and evaluative modes associated with creativity help children to understand their own creative thinking and decision-making, thereby facilitating their learning. The American 'Standards for Technological Literacy' define creative thinking as ''the ability or power used to produce original thoughts and ideas based upon reasoning and judgement'' (ITEA 2000, p. 237). Ritchie highlights the importance of creative thinking when designing.

> The key to successful designing is the ability of a designer (child or adult) to think creatively. Creative thinking involves a disposition of mind which is experimental,

open and engaged. A creative thinker is innovative and constantly searching for different ways of seeing a problem or situation. (Ritchie, 1995, p. 72).

For Keirl (2004) creativity is a way of expressing one's being, while Andreasen (2006) defines creativity more specifically in terms of originality, utility, product, person and process. The personality traits of a creative individual are ''openness to experience, adventuresomeness, rebelliousness, individualism, sensitivity, playfulness, persistence, curiosity and simplicity'' (p. 30). Openness to experience is related to motivation, which is examined below.

Motivation in learning

Over the last 10–15 years, there have been many investigations about the role of affective factors (beliefs, attitudes, expectations, emotions, attitudes, and motivation) in the learning process (Hanrahan 1998; Ryan and Deci 2000; Zusho et al. 2003; Denton and McKinney 2004—just to list a few) with the general understanding that affective factors greatly influence learning. Affective factors that accompany students' thinking can significantly facilitate or hinder learning. Gal and Ginsburg (1994) documented the importance of students' attitudes, beliefs, expectations and motivation in the learning of statistics and further research by Lee (1999) showed that students' attitudes were more positive when learning occurred in ''active technology-rich environments than when instruction follows the traditional lecture-based approach'' (p. 134). According to Pintrich and DeGroot (1990) affective factors like motivation and self-efficacy stimulate the use of metacognitive strategies such as self-regulation. Metacognition is critical to understanding how a task is performed (Schraw 2001) and indicates students' ability to monitor, evaluate and make plans for their own learning.

While all these affective factors contribute to a more or lesser effect depending on the task or learning, motivation is considered one of the underlying elements in children's engagement. Motivation is said to be extrinsic (related to external factors) or intrinsic (related to innate factors). Of these, intrinsic motivation is what drives students to complete a task or gain satisfaction from their personal achievements. ''… it is believed that motivation can be discerned through students' reports of their beliefs as well as through behaviours such as choice of activities, level and quality of task engagement, persistence, and performance.'' (Zusho et al. 2003, p. 1081).

Further research (Vansteenkiste, et al. 2004) suggests that students' level of control over their own learning actually facilitates the learning process. ''Learning is an active process that functions optimally when students' motivation is autonomous (vs. controlled) for engaging in learning activities and assimilating new information'' (p. 247).

Motivation and creativity

Torrance (1970) comments on the importance of the intrinsic motivation inherent in creative activities. While recognizing that extrinsic motivations may be effective in many instances, he discusses the limitations of reward and punishment because to keep learning progressing, these must be continuously applied. He identifies that ''creative ways of learning have a built-in power of motivation—the process only has to be encouraged'' (p. vii). Ryan and

Deci (2000) describe intrinsic motivation in terms of doing of an activity for its inherent satisfaction, and contend that both creativity and deep learning result when intrinsic motivation is high. Osho (1999) writes about the lack of recognition given to creative people, and is encouraging when he suggests that: ‘‘If you really want to be creative, then there is no question of money, success, prestige, respectability—then you enjoy your activity, then each act has an intrinsic value’’ (p. 100).

Intrinsic motivation can be affected by external factors such as the learning environment. If teachers attempt to exert control rather than provide guidance, and if deadlines and competition pressures occur, then motivation can be dampened (Ryan and Deci 2000). Giving students high levels of autonomy is also considered important in aiding creativity. Choice and self-direction enhance intrinsic motivation. In undertaking a technology task, using an open-ended design brief, students demonstrate the ability to ‘choose’ the features of the task for themselves, to engage actively in the task, and a willingness to persist. These three behaviours are traditional indicators of motivation (Pintrich et al. 1993). If we look at children’s language as an indication of motivation we would need to relate the behaviours to the language: expressions of personal choice, indications of involvement e.g. expressions around the task parameters (fun, enjoyment, satisfaction) and persistence (difficult).

The role of language

Osborne et al. (2004) consider language to be an integral and crucial component of the cognitive development of children. Although language and thought initially develop independently in children (McInerney and McInerney, 1998), eventually they merge through the social context in which children communicate with others. Teachers promote language development whilst recognising that children learn in different ways. This promotion can be through the provision of enriched learning experiences which include visual, auditory, small and large group aspects.

In terms of developing understanding, it is important that the language related areas of communication, connections and reasoning form a significant part of the child’s early learning (Lind 2005). Language is used to clarify ideas and also to include learning in everyday communications of discussion and listening. As children engage in learning, their language skills will become increasingly complex over time (Dockett and Fleer 2002). Mei-Hung and Jing-Wen (2005) in research on children’s understanding using multiple analogies, found that understanding of new ideas was limited if students did not engage linguistically with the material being studied. Research by Kamen et al. (1997) looking into the relationship between science/technology learning and language articulated the following: ‘‘With a constructivist paradigm dominating the field, language is being explored for its role in facilitating and assessing learning and in understanding complex interactions related to science teaching and learning’’ (p. 1).

The emerging literature on the ‘representations’ of children’s ideas highlights the value of teachers’ pedagogical strategies that focus on how students represent developing understandings. Current understandings of language depict it as a mix of verbal, graphic and written modes to represent the same and different concepts and processes. Understanding these modes, recognizing how they are used to construct explanations, and negotiating the meaning of different representations are crucial to learning in technology.

In this research on design and technology education, we worked with Year 4 teachers to plan and implement a unit with a strong representational focus, in which children were encouraged to develop multiple representations of their technology task, including annotated drawings, verbal accounts, and written texts. Through negotiation and guidance of children's representational choices involving drawings, we found that the children made significant advances in their understandings of different aspects of the task. This representational focus thus helped resolve difficulties children have with causal relationships and assisted them in the problem-solving process. The written component was guided by questions, but was left to the children to respond in whatever way they saw fit.

Teachers are continually exploring the benefits of oral language for developing children's thinking and reasoning-for example through questioning, responding to questions, dialogue and presentations. Written language, while not as expansive or as rich as spoken language, can still provide children with an outlet for communicating their thoughts or expressing their beliefs. Writing provides an opportunity for children to record their thinking, clarifying and focusing their thoughts along particular channels. The use of set questions provides a structure and framework while scaffolding an approach to thinking about the task they have been undertaking. A 'free' writing space (labeled–Any additional comments) allows individual remarks along other lines of thought. Written language can be seen as a way of children capturing their immediate thoughts and preserving them before they move onto other tasks. As children use language to describe their thinking, they are learning how to organize their conceptualizations in a manner that will be meaningful for themselves and others.

Need for the study

Consistent with de Vries' (2005) call for educational research in the areas of technology as artefacts, as knowledge, as processes, and as part of human nature, our study examined primary school children's experiences of technology as processes. Whilst the teaching of design and technology has been part of many school curricula for many years, experience and research (Webster et al. 2006) has shown that classroom practice is not well established and that there are many issues requiring research.

Research approach

In framing the study we drew on the well-established research approach of content analysis. In particular, this approach refers to 'in depth analysis' using a range of recognized methods, such as paying attention to objectivity-intersubjectivity, a priori design, reliability, validity, generalizability, replicability, and hypothesis testing (Neuendorf 2002). Kerlinger's (1986) definition (cited in Wimmer and Dominick 2000, p. 135) seems to be widely accepted, that is that ''content analysis is a method of studying and analyzing communication in a systematic, objective and quantitative manner for the purpose of studying variables''. Therefore, content analysis is an appropriate approach for us to assess the content trends in the children's written work in the study described below.

One aspect of the research we were particularly interested in exploring was to determine if the children's ideas shifted and changed across the period of their involvement in the technological task. Another feature of this analysis provided baseline data on the language children used at different times while undertaking various phases of the design task. While it is a form of content analysis, it is not a sophisticated form. In terms of the ‘‘uses of content analysis’’ (Wimmer and Dominick, pp. 136–137) we are using the technique in a traditional and descriptive manner. However, it is partly being used to infer children’s values and motivation about the completion of the technology task itself.

In undertaking our analysis, we considered the following questions (adapted from Krippendorff 2004).

Which data are analyzed? The data are all and any of the children’s writings in their ‘‘My Thinking and Ideas’’ booklet.

How are they defined? The data are defined in that they must only be children’s writings.

What is the population from which they are drawn? One booklet from each student, with a total of 80 booklets. Each booklet contained five pages for writing and five pages for annotated drawings.

What is the context relative to which the data are analyzed? The booklets from the two case study schools which involved four separate classrooms of grade four (9–10 years old) children.

What are the boundaries of the analysis? The boundary relates to the book and only to the writing. Children’s presentation material or informal discussions were not part of this study.

What is the target of the inferences? The target relates back to our original question—what is the role of motivation and what is its capacity to influence and engage children in the technology task?

Purpose of the study and participants

The purpose of the original study was to explore the effect of including an incubation phase (consisting mainly of a period of non-focussed thinking time) in the technological process. We were particularly interested in finding out whether the incubation phase enhanced the children’s creativity and we used a number data gathering tools to collect information on children’s ideas. One of these was a written record—a journal of thoughts. We invited one regional school in Geelong and one rural school in the Mornington Peninsula in south east Australia in the state of Victoria to participate in the study. Two regular teachers (at Year three or four level) from each school agreed to teach a technology unit during normal design and technology education times within the classroom over a period of three to five lessons. An initial step in undertaking this study was to ensure that the teachers had some idea about the development of creativity in design and technology education. Not all teachers were familiar with technology processes, so they were provided with informal information sessions, and a brief outline of the research related to creativity.

The design brief for the technological task

The children were set the task of designing and making a recycling device by implementing technology processes. The products to be made by the children should show functionality, creativity and be made as carefully as possible. Prior to starting the task the children were asked to collect materials and bring to school any items that might be useful for the construction of products. These items may include: plastic containers, small boxes, card, pieces of fabric, tubing, lids, foam, bottles etc. The technology task was described using the following open-ended design brief.

> Design and make a model of a small recycling device for the home or garden. Your product should be made mainly from recycled materials.

Data collection

In seeking the children's perspective on aspects of the technology task, the children were asked to record their ideas, sources of ideas and reflections on their participation in design and technology education in their copy of My Thinking and Ideas Book. They did this using annotated drawings and written texts. Verbal accounts also provided a confirmation of the accuracy and efficacy of the written recordings. The written responses and children's drawings provided information about the children's involvement in technological processes. For the first session children brainstormed ideas, and in all sessions the children could include drawings of their ideas and responses to the following questions:

- When doing the technology, what have you been thinking about?
- What are some of the problems you've had today while doing technology?
- How did you solve them?
- Reflections—What are your feelings or thoughts about any of the technology you have done today?

We decided that as the technology process was relatively new to some children and their teachers, some structure would be appropriate, to ensure that we captured the children's thinking. We also saw the questions as a form of scaffolding to an approach to thinking about the task they have been undertaking. The opportunity to add additional comments allowed the children to move into other thought areas not captured by the questions provided. Using a written mode also facilitated children's movement between the different aspects of the task and helped to reveal the relationships between the 'thinking' and the 'doing'.

In the final session, each child evaluated his/her product, and as an individual, reflected on the level of participation in the technology process by responding to the following:

- What did you call your product?
- Describe how it works.
- Describe what makes it look good.
- If you had different materials, what would you do?
- Describe how well you worked on this project.

Classroom observation occurred at each site during all aspects of the technology task. The researchers were able to observe both classroom interactions (teacher: child, child: peer) and the discourse. Anecdotally, it was concluded that the written responses correlated in sense, although not in volume, to the discussion children were having while engaged in their task construction. Interviews with and comments from the teachers at the end of the technology task also supported the written discourse from the children. As they finalized their models, children were given the opportunity to present their technology project to the whole class. Teachers indicated that children appeared to be engaged and highly motivated, ''…students are always interested and enthusiastic…'' They commented on the social aspects of the task and the sense of satisfaction that children exhibited on completing their projects. They talked about the frustration that some children exhibited, both with their own limitations and with the limitations of the available materials.

Data analysis and results

We read each book and looked for trends across the language used by the children. We found that there were consistent themes around which we were able to undertake a content analysis of each page of every booklet. Data analysis revealed that there were several key factors that children focused on such as: the fun of the activity, the satisfaction of completing the task, how difficult the task was at times, and some of the frustrations felt. Table 1 below shows the children's language in relation to motivational factors (fun, hard, nervous, frustrating and satisfaction), and social factors. The total number of books analysed was 80, comprising 38 for the Geelong school and 42 for the Mornington Peninsula

Table 1 Children's language about their technological activity

Factor	Children's comments—number and examples	Total/80 Children's Booklets
Fun	(10) Fun—because we get to draw, make what we are going to do (10) I think it has been really fun making something instead of doing work (7) I think it is fun we get to do this. This is fun. It is fun because it is creating something new. It was fun. I cannot wait to do it again (6) I think it was fun because I knew what I was going to say and do	30
Difficulty	(37) I think it has been hard to make my device. Difficult to get everything right (10) Hard because we have to think how and what we are going to use (13) Feel good, have fun and I think technology is sort of hard (29) I thought it was going to be easy, but even just planning is hard	17
Nervous	I felt nervous because I thought it would work	5
Frustration	I want to get it done because I've had enough! This has been a real pain	15
Personal satisfaction	(8) I think I worked really hard (10) I think I did really well (8) It felt good and I felt like I was a real scientist. (20) I felt happy and good and excited about technology (19) I think I did well with not much help (8) I was proud about my machine and how I solved the problems that I had. I felt proud because I completed the challenge. It was difficult but I kept going	66
Social interaction	(4) Teamwork and brainstorming (2) Felt good because we worked as a team (9) Co-operating and sharing. Annoyed because R wasn't there. T and I worked really well	17

school. Note that there could be several comments (bracketed numbers shown in column 2) relating to a particular factor (column 1) in any one booklet. The third column shows the number of children who commented about that particular factor.

Discussion of the results

Analysis of the children's language in the booklets tells us about their motivation towards the technological task. The open-ended design brief facilitated the children's intrinsic motivation. As design and technology education was fairly new to some schools in the study, the children were very interested and perceived engaging in the task as being 'fun' with 33 comments in 30 booklets. Closely allied to the comments about fun, were those relating to children's 'personal satisfaction' as a result of their achievement in successfully designing and making their recycling devices. 73 comments in 66 booklets illustrate that 'personal satisfaction' was of high importance to nearly all children (only 14 booklets contained no comments specifically relating to personal satisfaction). External motivation was evident from the 'social interaction' comments (in 17 booklets) that were generally very positive. Children enjoyed the opportunity to work together, and to share their ideas and cooperate with their peers. Most children valued teamwork and sharing (although some children hampered progress by forgetting to bring materials and being absent from some technology sessions). This co-operation between children was also evident from discussion with teachers and the observations during sessions. However, with little previous experience in designing and making products, some children described the task as being hard, indicating a high level of 'difficulty'. 89 comments in 17 booklets provide evidence to support the contention that for some children, the technology task was not a simple thing. Nearly a quarter of the children really struggled with the technology task. It is beyond the scope of this paper to explain why this happened but possible explanations include: task unfamiliarity, unstructured way of working may not suit some children, less teacher/adult support than required, ambitious task that was beyond some children's capabilities. Teachers also commented about the children who found this technology task hard by mentioning the children's persistence, and also commented on specific children whose background prevented them from solving issues as they arose.

Conclusion

In our concluding comments, we return to the research question:

> What is the role of motivation and what is its capacity to influence and engage children in the technology task?

From the research we can make several assertions. Firstly, children's written language identifies motivation as one of the strongest elements associated with technological activities. In particular, the finding that 'personal satisfaction' ranked ahead of 'fun' was an interesting finding in itself. This ranking seems to indicate that children do not need to have fun as long as they gain some sense of achievement and fulfillment from what they are doing. Many children appreciated the opportunity to work with others, and this interaction was linked with both teamwork (working together) and social situations (more relaxed learning environment).

As the children had a great deal of autonomy over their task, they demonstrated the ability to 'choose' the features of the task for themselves. They engaged actively in the task, and demonstrated a willingness to persist. As indicated earlier in this paper, Pintrich et al. (1993) determined that these three behaviours are strong indicators of motivation. Our investigation of the children's language use found that the language they used did relate to motivation:

expressions of personal choice, indications of involvement (fun, enjoyment, satisfaction) and persistence (difficulty).

Several limitations associated with the study have been identified. Many booklets were incomplete because the children were so engaged with making their products that they neglected to do the writing or they simply chose not to write. This lack of written answers to the questions affected both the quantity and quality of data collected. Another limitation resulted from the research approach that relied on written comments in the children's books, teacher interviews and teachers' anecdotal comments (not reported in detail here). As indicated above, not all children wrote extensively in their booklets, which limited the richness of the data obtained. Although some children responded to the 'free' space for writing, we wondered whether the questions may have constrained, as well as scaffolded, what some children wrote. In hindsight, it would have been valuable to record several of the children's discussions. However, as the study was relatively small, due to limited funding, the children's talk during their participation in the technological task was not recorded.

Thinking about the practical implications from this research, we would like to provide some comments for teachers. Engagement is the key to children wanting to learn and it is clear from our study, that motivation through the introduction of the three behaviours (student autonomy in task selection, active involvement in the task, and a willingness to persist) gave rise to all of these behaviours. The 'hands-on' nature of the task is one component that enables student autonomy but the learning does need to be embedded. Doing tasks just for 'fun' are not as satisfying for children as those which require some thought and effort for completion. The written language component of the task was essential in providing insight into children's thinking in design and technology education. Whilst interactive dialogue is a crucial element of any teacher's practice, it may not be enough. As indicated above, the written component offers children opportunities to consolidate their thinking and to clarify their ideas.

Future research could take the form of larger studies that involve tape-recording the children's oral language in the classroom as they participate in the technology process. Another useful form of data—children's voices—would be follow-up interviews with the children after the design and technology sessions. In this way triangulation of data (children's written comments, oral talk during sessions and follow-up interviews) would obtain a more comprehensive account of the children's perspective of various aspects of the technology process.

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