Constructivism and Problem-Solving: Multimedia Projects in Schools

Juliette D. G. Goldman and Julieanne Krause

Griffith University, Gold Coast Campus

Abstract

This case study investigates preparatory collaborative problem-solving employed by some upper primary school students in readiness for an interactive multimedia project undertaken by them. This study was set within the constructivist paradigm to enable students to construct their learning and build upon their knowledge through collaboration. Two groups of students, one each from Grade 5 and Grade 6 participated in the preparatory problem-solving exercises using de Bono's 6 Hats and Jonassen's Mindtools, and each group was required to work collaboratively. The group members were observed for the collaborative problem-solving strategies that they chose to employ. Evaluation of the study was also set within the constructivist paradigm, using Fourth Generation Evaluation (4GE) (Guba & Lincoln, 1989). This study showed that when students have experience in using appropriate problem-solving preparatory strategies for working with interactive multimedia programs, they are able to work collaboratively and more effectively in the construction of their knowledge in the project. It is recommended that problem-solving techniques be taught to all children working with multimedia programs to enable them to find useful and constructive ways of making informed decisions and group co-operation to achieve satisfactory learning outcomes.

Keywords: primary classroom, constructivism, problem-solving collaboration, interactive multimedia

Collaborative Problem-Solving

The learning environment in a classroom, developed by a cohesive collaborative problem-solving group, can promote an atmosphere of safety and trust, where students feel that they can safely take risks, make decisions and persevere with the required tasks (Bennett & Diener, 1997). When students work within groups they are communicating about their assigned tasks concurs Cohen (1994). In order to complete these tasks successfully, they need to ask questions, explain, suggest, critique, listen, agree and make joint decisions, as a group.

The main tenet for group project work is to provoke good discussions, to collaborate and provide a chance for all students to participate (Slavin, 1990). Students need to work with realistic problems in realistic contexts for any concrete learning to occur (see Duffy and Jonassen (cited by Smith-Gratto, 1995). Since problems usually have many aspects, students should explore multiple viewpoints in order to build networks of related ideas. All the skills used in problem-solving tasks within interactive multimedia require higher-order thinking skills, such as Bloom's Taxonomy which include knowledge, comprehension, application, analysis, synthesis and evaluation.

When students are motivated and actively engaged in learning, teachers can encourage them to undertake more productive activities (Slavin, 1990). However, students will not necessarily develop group and problem-solving skills (Baker & Baker, 1994; Cohen 1994; de Bono 1992). As de Bono (1992:42) notes 'the skills of creative thinking have to be learned directly in their own right'. Programs which are designed for thinking and problem-solving skill development often involve only learning strategies for remembering things, such as acronyms or acrostics (Cognition and Technology Group at Vanderbilt (CTGV) (1997). That group believes that appropriate problem-solving skills should incorporate strategies for breaking problems into parts, working backwards, as well as incorporating creative skills, brainstorming and abstract and lateral thinking; which should lead to defining and achieving the group's objectives.

Collaborative multimedia

Teamwork skills are a necessary part of technology education in schools (Barak & Maymon, 1998). This is not only because there is usually a shortage of computers, mainly due to the poor student-to-computer ratio within most schools (see Goldman & Hocking, 1999, 2000; Goldman & Krause, 2003), but teamwork also assists students in learning to work with and support others (Goldman & Krause, 2001). Goldman (1997) asserts that one of the most important principles of teaching is to stimulate active involvement in learning and using technology to facilitate this learning.

Although a number of interactive multimedia require the use of higher-order thinking skills, this does not imply that only gifted students can operate within a collaborative interactive multimedia group. Troxclair, Stephens, Bennett and Karnes (1996) found that most students improved their written and communication skills when they worked on a collaborative multimedia project. Boser, Palmer and Daugherty (1998) agree stating that students can further develop their higher-level cognitive skills by participating in technological

activities, which are group and problem-centred. This was supported by Cunningham, Angell, Morton and Cunningham (1998) in their study of the use of interactive multimedia programs in building literacy skills in 22 Primary School students. Their results showed that students not only improved their literacy skills, but also improved their communication, problem-solving and teamwork skills. The latter findings of the research were not initially sought after, nevertheless, the results were so evident that the students were able to affirm the findings.

de Bono's Six Thinking Hats

Problem-solving, as described by de Bono (1998), is the traditional area for creative, abstract and lateral thinking. He has developed many theories, the best known of them is the Six Thinking Hats (de Bono, 1985). The six colour-coded Hats are useful for classroom interaction and for multimedia problem-solving, as they allow a student to mentally change Hats and think in new directions about the problem, as in Figure 1 (see appendix).

Problem-solving can be simplified by using the six thinking Hats and the thinker can concentrate on one aspect instead of having to deal with information, logic, and disgruntled group members at the same time (de Bono, 1985). This form of problem-solving is ideal for interactive multimedia as it is procedural, can be undertaken at any stage of the project, and has a number of people contributing.

Another tool which assists problem-solving through the use of critical and lateral skills is Jonassen's *Mindtools* (1996). Jonassen developed a range of mind-tools to foster development and understanding of the skills involved in interactive computer programs. Multimedia Mindtools (Jonassen, 1996) assist in breaking down the problem, identifying the various facets, gaining an understanding for the complexities of the problem, and then working to solve the problem. In this way, Jonassen (1996: 193) believes, students will become constructors of their own learning, using multimedia to 'generate their own instruction . . . [as] . . . learners actively construct knowledge through multimedia, they acquire cognitive, metacognitive and motivational advantages over those who merely attempt to absorb knowledge'. This is especially visible, according to Jonassen (1996), as the building blocks of multimedia enable the constructor to change any part of the product during its construction. Graphics, video, sound and text can be resized, made to speed up or slow down, or even change colour. This extended form of free expression gives students ample opportunity to extend themselves, be creative, and become enthusiastic in their learning (See Goldman & Torrisi-Steele 2002).

Group Work and Skills

The definition of a group as given by Johnson and Johnson (1997: 9) is 'a number of individuals who join together to achieve a [common] goal'. However, Sturges (1995: 1) states that a group is 'two or more people who interact in such a way that each person is influenced by each other person in the group'. There are also many different types of groups such as task, focus, formal and informal. Whatever the orientation of a group or the size of a group, one thing is common, that the members of a group are meant to work together, and hopefully become united as one cohesive unit, to achieve their objective (Sturges, 1995; Johnson & Johnson, 1997). Sharing of goals and ideals creates an interdependence in the members of a group.

The progress of the development of a problem-solving group is also affected by the group members' values and past experiences (Sturges, 1995). Since problem-solving can incorporate the use of higher order thinking skills (de Bono, 1992, Jonassen, 1996), involving researching, formulating, expanding, assessing, comparing, and accepting, then decisions need to be made in a rational and objective manner. Collaborative groups must co-operate, and share both information and time (Jonassen, 1996). If this is not done in an equitable manner then the group may stagnate or even disintegrate (Johnson & Johnson, 1997).

A number of reasons hinder group development and decision making. The two main hindrances are social loafing and taking a free ride (Johnson & Johnson, 1997: 254). Social loafing occurs when an individual does not "pull their weight" in the group. It happens mainly when there is no strong incentive for the group member to perform his/her task, or when the input of all the group members is not clearly identifiable. Free riding is when one group member benefits from the efforts of the rest of the group, without having to contribute anything and it usually takes place when a member does not consider that the group output will be harmed in any way by their non-participation (Johnson & Johnson, 1997). This is different to social loafing, in that free-riders usually will participate if it is necessary, and if they think that the group would fail without them. In contrast, social loafers choose not to commit at all unless they are being assessed on what they contribute to the group (Johnson & Johnson, 1997). When a group has social loafers or free riders then conflict may follow.

Group conflict

Conflict within a group can be caused by members of the group lacking the appropriate interpersonal skills to be able to discuss the problems they are experiencing (Johnson & Johnson, 1997). Sturges

(1995) notes that when one group member is more domineering than the others are, then he/she may try to apply pressure on the other members in order to have his/her ideas accepted. However, 'a group with any cohesiveness at all has a built-in tolerance for differences of opinion' (Sturges, 1995: 3).

In order for a group to overcome conflict it must control the occurrence of conflict by reducing the barriers to problem-solving. These barriers may be internal such as values, fears, habits, and avoidance; or external such as noise, separation, or an inappropriate location for meeting (Johnson & Johnson, 1997). Controlling the occurrence of conflict depends on the commitment of the members and the maturity level of the members' social and communication skills (Johnson & Johnson, 1997). However, conflict within a group is not necessarily unhealthy. In fact, without occasional conflict, the group members would be exhibiting a non-committal attitude, or a dominant member would have taken control.

Method

This study aimed to examine the characteristics of the collaborative problem-solving skills used by some upper Primary school students as preparation for an interactive multimedia project. Since writing and compiling a multimedia project is time consuming and requires a number of skilled contributors, effective collaboration was seen as essential if the project were to be completed. It was realised that such a project may become splintered if students were not helped to gain collaborative problem-solving skills. The Year 5 and 6 students in this study appeared to need preparatory problem-solving experiences before any such multimedia project could be started. This study analyses these preparatory problem-solving exercises.

The case study was conducted while the students worked in two groups, one of Year 5 students and one of Year 6 students, each containing four participants. Each group was later required to design and develop an interactive multimedia project which would involve a wide range of problem-solving, when it would be necessary for the students to be able to freely gain an understanding of the problem, discuss it with their partners, find a solution and then implement it. That is, they needed to be effective collaborative problem-solvers in order to complete the multimedia project. Therefore, introducing the students to two forms of problem-solving techniques, such as de Bono's six Hats and Jonassen's Mindtools, enabled them to have the experiences of appropriate models of how they might collaboratively solve problems.

Sample

For the purposes of this case study, it was necessary that students had little prior problem-solving instruction, nor cooperative learning skills. However, they needed moderate interactive multimedia programming and multimedia project experience. Therefore, a purposive sample was used (Rubin & Babbie, 1993; Fetterman, 1998). Two groups of four children (n=8) were selected from a small private school located on the New South Wales/Queensland border. In each group, one from Year 5 and one from Year 6, there was an equal gender mix of 2 boys and 2 girls. They had all played interactive educational computer games and used basic *Windows* programs, such as *Microsoft Works 4*, *Word for Windows*, and *Publisher*. All students selected had been taught computer keyboard and program navigational skills in computer education classes at school and were considered to be competent academically and in computer skills.

Social background

All students came from a similar mid-range socio-economic background, attended the same private school, and lived in the same community. One of their parents had participated in tertiary education, and seven parents out of the eight were working professionals. All families had either a computer in their home or access to one outside school hours. All families willingly gave their consent for their child to take part in the study, and to provide background information about his/her family and to allow follow-up interviews if necessary. The School Principal gave consent for the study, conducted during school hours, and viewed it as an advantage for the students to be able to gain new knowledge while contributing to educational research.

Fourth Generation Evaluation (4GE)

The central role of 4GE, according to Guba and Lincoln (1989), is for researchers to enable the other stakeholders to reach consensus on one or more constructions, which will facilitate a conclusion and recommendations by all stakeholders. Guba and Lincoln (1989) explain that the role of the researcher needs to change from the conventional, investigative judge, to that of a teacher/learner role, in partnership with the other stakeholders in the study. They assert that the researcher needs to be aware of the leadership role that they play in assisting with the construction of the research data. The researcher becomes an active participant who helps shape the end product, which is not necessarily an object, but a new reality for the stakeholders. Even though the researcher is an observer for the majority of the time during the study, he or she is still influential during the time of instruction and according to Guba and Lincoln (1989) is, therefore, an agent of change. 4GE is viewed as a part of a continual process, 'where

the product is continually recycled and updated through the use of divergent processes and reconstruction' (Guba & Lincoln, 1989: 263). This approach of 4GE was used here.

Data Collection

The data was gathered via a number of modes, including observations of the students as they worked within their collaborative project groups. Open interviews were conducted with the eight participating students and their teachers to record their estimates on the progress being made with the project, group collaboration and development of problem-solving skills. Some collaborative group problem-solving sessions were videoed to assist with the confirmation of written data gathered during observations. The main principles of the data collection were to use multiple sources of evidence, create a data base on the information gathered, and maintain sequential evidence of the data collection (Yin, 1989).

The data collection continued over two school terms; a period of 17 weeks, with a 3 week interval of no data collection during the mid-section of the study. (See Table 1 in appendix). Data were gathered from written records of observations, videoed observations and recorded interviews. A follow-up interview with each student took place, during which notes were taken. This assisted with triangulation and participant validation. From a constructivist perspective, and given that the participant is aware and has a sense of self, then the participant becomes a stakeholder in the study and the validation and evaluation process (Stake, 1998). The students are known throughout the study as G (for girl) 1 and 2 and B (for boy) 1 and 2. The year 6 cohort has a 6 prefixing their code (e.g. 6G1), and the Year 5 has a 5 (e.g. 5G1).

The Setting and Equipment

The study was conducted in the computer lab at a small private community school. The lab is in an ante-room connected to a classroom used by the Year 4 students. Although the room is small, it accommodated the two groups comfortably on the carpet area when they were working on problem-solving activities. However, the room did have serious ventilation problems during the first term, as it was still summer and the room had an east-west aspect, allowing the afternoon sun to stream in and heat the room considerably. Also, as the school was located close to the highway and the airport, it experienced a great deal of noise pollution.

The two computers, used for this study, were placed at one end of the room, where space was cleared and made available in between the computers, to allow for a workbench. The computers available for stu-

dents were IBM compatible clones with a large memory and RAM capacity comparable to the latest in available hardware. They were loaded with *Windows 98*, and the software used in this study included *Authorware 4*, *Photoshop*, *Word 7*, *Works 4* and the *Windows* sound recorder. Scanning equipment and the Internet were also used for downloading graphics and information for the projects. As the monitors did not have built-in microphones, it was necessary to fit a portable microphone for sound recording.

Collaborative Problem-solving

Each week the groups used the computer lab for three sessions. Two sessions were used for preparatory collaborative problem-solving skills instruction, development and activities. One session per week was dedicated to training the students in computer programs which they would use in their project. All members of both groups were informed that they could meet and discuss their project at any time they wished; they did not have to wait until they were having a group session in order to do so.

Student Groups

The two groups of volunteer students consisted of two boys and two girls in each group. One group was from the Year 5 cohort aged 10 years, and the other group from Year 6 aged 11 and 12 years. The students in each group had been together as classmates during the past year. For research purposes, they worked either individually, or as a group. Each group was responsible for its own project, and accountable to each other for their input to the group. The groups were informed that group consensus must take place with any decisions made, and as they were all stakeholders in the information input, they were then responsible for the decisions made by their group.

During the course of the study the groups decided that they would need to have "experts" within their group, so the tasks could be divided among the group, and they could work more effectively. These experts were assigned to different tasks which required gaining knowledge about different program areas. The chosen experts from each group were taught about their program so that they could then share their knowledge whilst working with their group.

The collaborative working of two groups will now be addressed separately.

Results

The Year 5 group

All students displayed capabilities in different areas, such as sound

recording, graphics/art, program navigation and researching materials. All members showed strengths in communication. However, two of the group members initially displayed individualistic tendencies, rather than collaborative working skills. There were many times when this group failed to make a consensus decision and they often resorted to the democratic process, that is, by using voting, as another option. Consequently, some students usually did not have his/her needs met by the rest of the group and he/she had to compromise. By the end of the study this group was able to work well cooperatively. However, they could not be described as a cohesive unit.

The Year 6 group

This group included a broad range of personalities and complex inter-personal issues often arose, particularly from one student who continually chose to withdraw or was determined not to contribute to the workload with the rest of the group. However, the other group members continued to work cooperatively during this study and found a new sense of self in being entrusted with a task that they were able to complete. All group members did agree to share the research workload.

Group Problem Solving Activities

The groups were instructed in the skills of lateral thinking and problem solving using de Bono's 6 Hats. Students were asked to undertake certain tasks and problems where they were either to use all of the 6 Hat processes, or they were to break into pairs using 3 Hats or only 1 Hat at a time. As well as the lateral thinking simulation exercises, the groups were asked to participate in construction exercises, which involved observation, collaboration and construction of a "concrete" model.

Preparatory collaborative activities

Exercises using de Bono's 6 Hats

One group activity involved a simulation exercise where a plane had crashed in the middle of the desert. The students were given a list of items which they could salvage from the wreck. They were also given a list of who the survivors were and what their occupations (if any) were. The students were then asked what they would do to survive. This exercise provoked a lot of discussion, in both groups, and it took some time to bring the groups to consensus. At the end of the exercise they all agreed that they would not have come to a consensus without using the 6 Hats, because they were having difficulty overcoming their bias, fears and prejudices, which were identified, by both groups, during the process. Table 1 shows the activities and the observational outcomes (see appendix).

The beaded wave

Another problem-solving activity included the construction of models using connecting beads and blocks to form a wave. The groups were given a model to touch, look at and inspect closely for two minutes. Then they had to construct a replica of the model they had been shown, within 10 minutes. All group members worked well on these activities. Especially where one model involved five long rows of beads connected to each other, and then twisted to form a wave shape and then locked into that shape by strands of supporting beads.

The Year 5 group discussed the model, and each person pointed out parts of its construction. When they were required to construct the model, they set out by individually building long strands of beads, while one member joined the strands together and continued to check with the model to see it was accurate. 5G1 was usually the main constructor, while 5G2 often gathered beads and kept building whatever part she was asked to make. 5B1 assisted in building and often checked on 6G1's progress. 5B2 often gave verbal input, but did not contribute to the construction of the model. Even when he was prompted by one of the other members, 5B2 would just shrug and opt for the social loafing role.

The year 6 group had difficulty in conveying how they perceived that the model should be constructed, so they built mini models to display their ideas. This assisted with the rest of the group opting for one of the methods. 6G1 took over the main construction, while 6B1 and 6B2 quickly constructed the links for joining together. 6G2 was free-riding during this exercise and made it clear that she chose not to take part in the exercise. However, even though they built two mini-models as well as the proper sized model, they finished in an excellent time of seven minutes.

The centred cube

The next activity introduced a cube model where there were only three colours used in the construction of the cube. Each group was given 15 blocks in three colours. The quantities of the colours were not entirely precise. To make it a little more interesting for students, an extra one of the other colours in the cube was substituted for what students would have assumed was a red for the centre of the middle row. Then, other different colours were inserted, which were different to the model on show. Each group was given different colour mixes. For example, 14 of one colour (brown instead of red) which is for the centre of the cube, then 4 blocks of another colour (blue instead of white) which is for the middle row, and then 9 blocks of a third contrasting colour (black instead of yellow) which is for the top and bot-

tom row and the block which would replace the other colour in the centre of the cube. These blocks were in a paper bag so the colours could not be seen by the groups until they were asked to begin construction.

Before the groups were given a model to look at, the researcher asked them to identify the shape. They all responded “cube”. The students were asked how many blocks they thought were in the cube. Three out of the four Year 5’s answered 54. However, 5B1 replied 27. The Year 6 group remembered the consensus rule and discussed the question before answering. They looked at the cube and were reminded by 6G1 and 6B1 that it was made from solid blocks, so there were only three levels of nine blocks, which meant 27 blocks were in the cube. The Year 6 group was congratulated for remembering the consensus rule.

The groups were given a time limit of 5 minutes to construct the cube. Upon opening the paper bags both groups exclaimed “foul play” as the blocks were not the same colours as the model. 6G1 and 6B1 were quick to count out the blocks and find that number of blocks in each colour did not correspond with the model. Once again the accusation of foul play was made.

The Year 5 group was again dominated by 5G1, who quickly grabbed all the blocks and started constructing the model without any consultation with the other group members. When she realised that they did not match, she stopped and asked for input from the other members. This delayed the group for some time because they decided to restart by counting out the colours and matching them to the corresponding parts of the model.

Meanwhile, the Year 6 group had divided the cube into its three levels. Then they constructed the top and bottom levels, viewing what blocks they had left over. All members then quickly concluded that the extra colour left over went in the centre of the middle level, as it did not matter what colour it was because it could not be seen. During this activity all members of the year 6 group were alert, active and very talkative; vibrantly discussing their ideas and deciding on what options to take. 6G2 was also an active participant in this exercise. 6B2 and 6G1 did most of the construction while 6B1 directed the construction by continually observing the progress and checking it with the model. 6B1 also kept the discussion going and kept informing the constructors of their progress.

Discussion

The Preparatory Exercises in Collaborative Problem-Solving

The collaborative problem-solving exercises themselves appeared to be most successful, in that there was positive transference of the use of de Bono's 6 Hats techniques (See Table 1). This method was so popular that the groups continually talked about it with their classmates and asked to have some whole class exercises using the 6 Hats.

The Year 6 group constantly used the 6 Hats method, even during discussion on the groups' progress or in conversations with a researcher. 6G1 and 6B1 often identified a statement of affective behaviour as the "red hat", or when they were asked to give information they would recognise that they were using the "white Hat" (See Table 1).

The exercises entailed the construction of models, which provoked a lot of discussion, positive and negative, in both groups. The Year 6 group stated that they had assumed the objectives of the exercises were to work collaboratively to solve the problems. At that time, their conclusion was not clarified. However, Year 5 aimed to "build a model and win". The Year 5 group remained competitive throughout the study and a lot of their discussions during the exercises were about how fast the task should be done and who was working faster or more effectively.

The Year 6 group's discussion was focused on "how" to complete the task together, and "how" to keep all members focused on the task. It was interesting to observe when they were not able to agree on a construction method during the beaded wave exercise, and how 6G1 and 6B1 built mini-models of what they were thinking. Then they discussed their models with the group, assisting the other members in gaining an understanding and making an informed choice. This supports Smith-Gratto's (1995) finding that realistic problems and contexts promote concrete learning.

Collaborative Problem Solving Characteristics and Choice

Six out of the eight students could confidently use the strategies of de Bono's 6 Hat thinking during the exercises. However, not all students could employ those strategies and techniques when faced with a problem, while constructing the multimedia project. It is doubtful that this was due to a lack of positive transference, as they had all displayed that they had the appropriate knowledge. During discussion, the students said that sometimes they "just forgot" to use any of the learned techniques, and sometimes they chose not to, as they were "mad at someone". Once again value judgments and responsibility for

one's own actions were prominent (See Johnson & Johnson, 1997). During the discussion a number of interesting pieces of information were gathered, which assisted in linking the issues of conflict within the groups.

6G1 and 6G2, who were often the instigators of conflict within their group, became close friends. 6G2 stated that she did not like the "attention" that 6G1 received from the boys in the group, and she did not like the way 6G1 and 6B1 were always working together. This confirms that some students responded or behaved in a group according to their own beliefs, values and needs. 6G2 displayed a lack of intrapersonal and interpersonal abilities. It became evident during the exercises that 6G2 was only focused on meeting her own needs. She was not able to share her needs with the rest of the group, as she was too embarrassed and felt that she would just risk rejection from 6G1 and the other members of the group if she made her feelings known. Unfortunately, for 6G2, this only led to frustration, acting out behaviour or withdrawal. The Year 6 group continually tried to include 6G2 in their discussions. However, 6G2 eventually withdrew from the group without displaying any attempt to use problem-solving strategies.

6B1, 6B2 and 6G1 agreed that without having the knowledge of using the problem-solving techniques they would not have been able to find solutions for some of the problems that occurred. 6B1 identified the useful ways in which the 6 Hats could be used to find solutions. For example the group often used brain-storming to find ideas for graphics and buttons. Then they would use the 6 Hats to make a selection from those ideas. The year 6 group also used the 6 Hats method to analyse the construction development. The group members would look at the project and discuss each screen using the 6 Hats (See Figure 1). The year 6 group stated that by using this method they were able to scrutinise their own work individually and collectively with the group and not "get upset" when comments were made about the work.

Using Multimedia Programs

Four of the eight students accomplished a high level of achievement while working on the multimedia programs. 5G1 was able to effectively manipulate graphics in the *Photoshop* program. She often used this program for computer art as it allowed her a greater choice of options than basic paintbrush programs. 6G1 also developed an excellent understanding of the *Photoshop* program and became adept in overlaying graphics and text and reshaping images.

5B1 was comfortable using the *Authorware* program and was able to link the framework with navigational commands. The knowledge he gained through the study was remarkable. He was able to proceed through the navigational processes of the *Authorware* program easily. He constructed complex buttons and hot-spots within the framework of the project. 6B1 also learned the basics of the *Photoshop* program from 6G1. Likewise, 6G1 became a capable *Authorware* designer. Through 6B1's instruction she was able to move through the different levels of the project's framework, loading graphics and manipulating the contents within the *Authorware* program.

Interest in Hardware

A sub-set of findings was that four of the students gained a growing interest in the different functions of computer hardware. Through discussions with these students they explained that they had recognised the different specialty parts within the computer, and how those parts were needed for the different programs used. They realised, for instance, that a sound card was necessary for the production of sound. The students had processed a greater understanding of the working of a computer and how programs were implemented through the computer. This also led to greater problem-solving capabilities when there was a problem with the computer. During the course of this study these students were appointed as school computer monitors within the school, as they were able to trouble-shoot problems, disassemble, move and reassemble computers when required.

Conclusion

Since six of the eight students were confidently able to utilise problem-solving strategies during the collaborative exercises, it is concluded that the instruction of problem-solving strategies enhances the learning capabilities of students. Five of the students, as well, were able to transfer the knowledge of problem-solving strategies and utilise them while working on multimedia programs, which confirmed that positive transference had taken place for them.

The use of collaborative problem-solving strategies while using multimedia programs had enabled these students to work effectively as a group and as individual members within their group. The students' construction of knowledge enabled them to use the problem-solving strategies while working in other areas, such as research, developing a flow chart and writing text-based information.

Recommendations

To assist students in developing a solid learning process, the results of this study suggest that teachers may assist children's learning by

implementing a constructivist paradigm when incorporating computers into the curriculum. By utilising interactive multimedia programs the teacher and students can access, create and develop a learning process, which will help students construct knowledge, recall and comprehension.

It is recommended that problem-solving techniques be taught to all children working with multimedia programs, to enable them to find ways of making informed decisions.

A further recommendation is for all students to be taught that their personal values and experiences can impact upon their group behaviour and the choices they make.

The findings show that conflict issues arose mainly from the lack of interpersonal or intrapersonal skills, and not from any form of gender bias or inequality of access. It would seem useful, then, to examine further the links between a lack of interpersonal/intrapersonal skills and/or a lack of problem-solving capabilities. It may well be that by enhancing communication and self-esteem, problem-solving capabilities may be enhanced

This study showed that when students use appropriate problem-solving strategies, while working with interactive multimedia programs, they are able to work collaboratively and more effectively in the construction of their knowledge. Even though the Year 5 group could not be classed as cohesive, two of the four members displayed excellent collaborative group skills. A variable which was not included specifically in this study which has since become prominent, is that the Year 6 group worked more effectively than the year 5 group, but the Year 6 group has had an extra year of computer tuition. It was surmised that since all the Year 5 students had received training in the basic areas of computers and they had played interactive games, that such differences would be minimal. It is difficult to determine if computer knowledge or age/maturity of the Year 6 group was the variable of greater influence. It may well have been the confluence of both. If this study were to be replicated, it would seem appropriate that two groups of students should be selected from the same grade and class to address this query.

Finally, the study was effective from the viewpoint that there was positive transference of the collaborative problem-solving skills into the interactive multimedia development. The constructivist paradigm was used and the students displayed effective learning as they were facing real problems in context with real demands on what they were

developing and what they had to produce as a group. Interactive multimedia is an advantageous learning asset to the educational system, and when properly utilised can assist in promoting the learning process for students.

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Appendix

Figure 1: de Bono's 6 Thinking Hats and their attributed processes.

White Hat	Is neutral and objective. Looks for the FACTS!
Red Hat	Suggests anger (seeing red rain with emotion. How do you FEEL about it?
Yellow Hat	Is for sunny and positive. What are the GOOD points?
Green Hat	Is for grass, vegetation and nature where everything is new. Let's have some NEW IDEAS.
Black Hat	Dark and storm loom and negative. What are the NEGATIVE aspects of this problem?
Blue Hat	Cool and the colour of the sky, which is above everything else It's in control and oversees all below it. Let's put it into some sort of ORDER and ORGANISATION for the final thinking process! _J

(Adapted from: de Bono, *Six Thinking Hats*, (1985: 31-32).

Table 1 Sequence of group activities and observational outcomes.

Week/Session	Activity	Observational Outcome
Week 1	Selection of group members. All students in the year were given an opportunity to 'try out' out for the study. Students sat in groups of 4 (always 2 boys and 2 girls), participated in basic group work and problem-solving activities.	More an ethical/equality issue for the researcher than a selection process. The researcher felt that the whole class couldn't participate in the study, they needed to be acknowledged. Group members selected.
Week 2 Session 1	Discuss with the group what will be expected of them during the study: namely to develop an interactive multimedia project, work in groups, and group decisions are to be consensual.	Group members drew assumptions as to what research was being conducted; some decided it was on computers, multimedia or how students used computers.
Week 2 Session 2	Introduce de Bono's 6 Hats. Exercises - orienting the different coloured Hats and functions involved in problem-solving using this method. Used a number of hypotheticals, e.g. "Too much money is spent on the Olympic games".	A lot of discussion on ethics, equality of funding and access. No participant sure on how to use the Hats, as yet.
Week 2 Session 3	Discussed project, topic areas, audience, and types of programmes to be used. Modelled programme usage and answered questions about navigational requirements.	Groups decided on using experts for programmes. Discussing topics for projects and audience age level.
Week 3 Session 1	Hypothetical using de Bono's 6 Hats. "To allow for a longer lunch, school will now finish at 4pm ". Instructed groups that they must name the type of Hat that they are using before they contribute to the discussion, e.g. Red Hat before making an "I feel" statement.	Some participants not using 6 Hats during discussion, quite a few "I" and "you" statements being made, definitely at the storming stage of group development.
Week 3 Session 2	6 Hats activity; "Build a better Spaceship". -group to design & draw a spaceship, labelling the parts and giving instructions for the functions of the parts of the ship .	A lot of discussion in both groups. Year 6 group reminded year 5's to use 6 Hats. Students all participated but had trouble making consensual agreement. Compromising was used.
Week 3 Session 3	Groups nominated experts for the programmes to be used. Instruction began in those areas.	Groups made appropriate choices in selecting expert areas.
Week 4 Session 1	6 Hats simulation exercise; "Plane Crash in Desert"	A number of bias/ethical issues arose. Groups unable to make consensual decision. Used 6 Hats in more flexible manner.

Table 1 (continued)

Week 4 Session 2	Begin construction exercises in collaborative problem-solving; "The Beaded Wave".	A lot of interaction and discussion from groups.
Week 4 Session 3	Practising / exploring the programmes and expert areas	Great deal of discussion as group members showed other members different aspect of programmes
Week 5 Session 1	Construction exercise; constructing "A Cornucopia Cone with Connecting Beads".	Year 5 (G1 leading) tried building with circles - year 6 used lateral thought - dissected the cone and realised it was rectangular (6G1 & 6B1) both found solution.
Week 5 Session 2	Discuss flow charts for projects' Modelled flow chart for project building	Students understood concept.
Week 5 Session 3	Practice programmes & put a dummy run together using all facets of multimedia production	A great deal of discussion - Problem-solving techniques was not used b Year 5.
Week 6 Session 1	Construction exercise "The Centred Cube" using coloured blocks.	Good exercise, Year 6 used Problem-solving techniques & worked collaboratively
Week 6	Groups work on flow chart.	Progressing well.
Week 7	Exercises cease groups now working fully on projects.	Observations continue.
Week 8, 9, & 10	Groups developing projects, technical instruction continuing	Observations continue.
Week 11, 12, & 13	No session during this time. Groups left to see if they would work without sessional times	Little progress made. 6G1 and 6B1 tried working at lunchtime. Claimed that it was too difficult constant interruptions.
Week 14	Group discussion - debriefing on progress and group dynamics	Observations continue with discussions.
Week 15, 16 & 17	Groups continue to work on projects Discuss progress with individual participants.	Observations continue with discussions.