Children, robotics and problem solving: Technology in the early childhood classroom

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Successfully educating children in technology means engaging them in purposeful activities which draw upon children's existing understandings and skills and moves them to more sophisticated knowledge and critical reflection of technological processes and products. (Fleer & Sukroo, 1995)

Introduction

In this age of constant change for teachers, we are constantly seeking reassurance that we are maintaining an environment that is truly conducive to learning. Trying to understand and implement the introduction of new technologies and processes is certainly a challenging one. Included in these processes are such decisions as: choosing and using appropriate technologies; designing, making and appraising technological processes and products; and applying and developing materials, information and systems. This direction includes using technologies such as computers and robotic tools.

The idea of children programming using computers and robots certainly isn't a new one. Logo has been in our schools for many years. Seymour Papert (1980) the father of the Logo programming language saw "children as the active builders of their own intellectual structures". Papert's own book, Mindstorms: Children, computers and powerful ideas (1980) opened up a whole new world for children involving the use of a programming language. He explained that children can learn to use computers in powerful ways, and that learning to use computers can be a major influence on the way they learn everything else.

However, young children can also experience the benefits of using a programming language through a robotic device, such as the Valiant Roamer Robot. The Valiant Roamer Robot is a commercially available floor-crawling, round battery driven robot which looks like a giant 'Smartie' on wheels. It is a robot, independent of the computer and uses LOGO type commands. The control panel on the top of the robot is colour coded and easy to use. It has clear symbol, letter and number instructions which allow young children to program the robot to perform various tasks. These tasks include basic movements such as forward, backwards, left and right turns, using pre-determined Valiant Roamer Robot lengths which equal 30 cm or the robot's body length.

Aims of The Study

The study reported in this paper was concerned with exploring the various strategies young children (early childhood) use while immersed in a problem-solving environment and whether introducing these children to a computer programming language activity through the use of a robotic device (Valiant Roamer Robot), influences their choice of strategy.

Specifically, the study aimed to answer the following questions:

1. What are the characteristics of the problem-solving strategies young children use when engaged in a given task?
2. To what extent do children reflect on their learning experiences with teachers and peers while immersed in a problem-solving environment?
3. What effects does exposing young children to a programming language, via the Valiant Roamer Robot have on their problem-solving strategies?

Metacognition and Problem-Solving

We all recognize that most school learning requires the gradual development of various sets of skills, attitudes and abilities, including the ability to reflect on one's thinking, language and learning and to monitor one's learning according to this knowledge. This latter set of complex skills is often referred to as 'metacognition' - an individual's ability to understand and manipulate their own cognitive processes (Marzano, 1988; Reeve & Brown, 1984). According to Cullen (1987) these abilities and skills are inherent in an active strategic approach to learning. In particular, at the preprimary level a strategic approach to learning is readily observable through a child's purposeful use of resources and equipment, the use of their own language to direct themselves and others, and in their persistence in following through on a challenging activity. These repeated patterns of strategic behaviours are considered to reflect metacognitive activity.

The Sample

An interpretive research methodology was employed to address the key research questions. The study sample comprised 6 children, with an age range of 4 - 5 years, chosen from 28 others according to their scores on the Matching Familiar Figures Test (MFFT). This test measures how a child thinks or reflects during the problem-solving phase of an activity (reflective thinking is an attribute associated with a strategic learner). Students' scores were classified into the following four categories: reflective, impulsive, fast/accurate and slow/ inaccurate. Two students were randomly selected from the first two categories (these two dimensions were considered the two main areas of differentiation between preprimary children) and one each from the categories related to speed and accuracy.

Research Design

The overall research design of this study involved both qualitative and quantitative components. The data sources for the quantitative part of the study were: 1) the student responses to the Matching Familiar Figures Test (MFFT) and 2) a special instrument, the Preprimary Problem-solving Observation Instrument (PPOI), was used to analyse and code the video tapes of lessons, activities and field observations. It attempts to measure the occurrence of strategic learner patterns of behaviour and the extent to which children reflect on their learning experiences with teachers and peers, while immersed in a problem-solving environment (Cullen, 1991; Williams, 1992).

The data sources for the interpretative component consisted of: 1) descriptive field notes of classroom observations; 2) video tape recordings of classroom activities related to student interactions with the Valiant Roamer Robot; 3) focussed semi-structured interviews with students, and 4) student drawings of their designs during set problem-solving tasks.

The study comprised three distinct phases: with the first phase focused on the administration of the Matching Familiar Figures Test (MFFT); the second phase was specifically designed to collect baseline data on the six case study children (in order to determine the problem-solving strategies the children were using prior to the introduction of the Valiant Roamer Robot); the third phase was spent introducing the children to the Valiant Roamer Robot and its basic commands, and setting the children specific problem-solving tasks to use with, and without, the Valiant Roamer Robot. The time line and sequence of activities, for phases 2 and 3 is outlined in Table 1.

Videotapes of lessons and activities were used to consolidate the observations made by the researcher with specific reference to the task related behaviours outlined in the Preprimary Problem-Solving Observation Instrument (PPOI). From these data emerged individual student profiles. Also, data obtained for the interpretative component - the descriptive field notes of classroom observations, semi-structured interviews and student drawings, etc - were analysed to identify patterns amongst the data, so that some basic inferences or assertions could be made concerning the students, the robotic device and students' reflections on their problem-solving activities. Table 2 displays an example of a student profile - Adam.

Adam's profile can be interpreted in the following way. During the pre-robotic phase, Adam who had been classified as a reflective case according to his MFFT results, did not exhibit behaviours which reflected planning a solution to a given problem. He was also rarely observed monitoring and evaluating his efforts. Adam didn't appear to have any difficulty redefining a set task in his own words or making use of the resources given to solve a problem. If Adam had a problem he couldn't solve he was rarely observed asking help from the teacher or his peers. However, he was willing to help others if help was sought.

There was a noticeable increase in those behaviours which reflect a strategic approach to his learning in the second observational period, (post-robotic). Adam was observed planning solutions to problems by identifying potential errors, predicting results and sequencing operations to perform. He also monitored and evaluated his given tasks more closely. Adam was observed to be a very social boy who was rarely on his own, and on many occasions during the post-robotic stage, Adam was observed frequently helping others and responding to requests for assistance. For example:

> The researcher asked Kevin to program the robot to return. Adam immediately goes to help Kevin and points to the keys he needs to press.
> (Week 4)

> The two children collaborate - Adam dictates and Sandra follows his directions, i.e. to build a bridge for the robot to pass under. Sandra has difficulty remembering the procedures and on various occasions during this session Adam goes to help her.
> (Week 6)

Most of the observational data gathered regarding Adam's problem-solving behaviours (Table 2) reflected those of a 'strategic learner'. For example: on some occasions he clearly demonstrated self-correcting qualities by identifying his own errors (as well as others) and then correcting them. Similarly, in the task relating to building a bridge for the robot to pass under,

> He programs the robot to move forward, but it didn't appear to be doing what he wanted. Before the robot stops Adam raises his hand to his head and comments, "I forgot to tell it to forget".
> (Week 6)

Discussion

The overall interpretation of the large amount of qualitative and quantitative data collected over the 6 week period, enabled the researcher to formulate a number of inferences based on the key research questions that guided the study.

Depending on the task, children of this age (4-5yrs) can demonstrate behaviours associated with both 'strategic' and 'non strategic' learning strategies.

The case study students - Kevin (slow/inaccurate), Sandra (impulsive) and

Table 1: Time on task for each selected activity

Week 2		Baseline Data The purpose of this phase was to determine typical strategies the children were using while solving problems.
Tue	**9.30-10.30**	**Interview three of the case study children (approx. 20 min each).**
Wed	**9.30-10.30**	**Observe two case study children during routine tasks assigned by the classroom teacher.**
Thur	**9.00-12.00**	• **morning mat routine-greetings/prayer, job roster, daily fitness, modelled writing, news.** • **indoor/outdoor activity time** • **concept mat time** • **fruit & snack time** • **story or game after fruit** • **continuation indoor/outdoor activity** • **music & movement**
Fri	**9.00-12.00**	**Observe another two case study children (as above).**
Week 3		
Mon	**9.00-12.00**	**Observe the remaining two case study children during routine tasks.**
Tue	**9.30-10.30**	**Using the materials found in the block corner two case study children are asked to help each other build a house for a giraffe to live in during the winter.**
Wed	**9.30-10.30**	
Thur	**9.30-10.30**	
Week 4		Introducing the Valiant Roamer Robot The children were unfamiliar with the Valiant Roamer Robot and needed to be shown how to program the robot .
Mon	**9.30-10.30**	**Introduce the Roamer and its basic functions to the case study children**
Tue	**9.30-10.30**	**Three children per session - Reinforce basic commands and set simple problem tasks for them to complete.**
Wed	**9.30-10.30**	
Thur	**9.30-10.30**	
Week 5		
Mon	**9.30-10.30**	**The case study children to instruct their group (assigned by the classroom teacher) on programming the Valiant Roamer Robot.**
Tue	**9.30-10.30**	
Wed	**9.30-10.30**	
Thur	**9.30-10.30**	
Week 6		Problem tasks using the Valiant Roamer Robot The children were asked to employ the skills they had learnt in earlier sessions to program the robot. The sessions were recorded, and later analysed to identify the problem solving strategies they were using during these specific tasks using the Robot.
Mon	**9.30-10.30**	**The children were asked to complete the following tasks:**
Tue	**9.30-10.30**	• **Build a bridge for the Valiant Roamer Robot to pass under, stop prior and knock down (2 children).**
Wed	**9.30-10.30**	• **Use the magnetic cards to program the robot and display the procedure, set a procedure and follow it, set a procedure for someone else to follow and follow a procedure that has been set by the researcher (3 children).**
Thur	**9.30-10.30**	
Fri	**9.30-10.30**	
Week 7		Problem task without the Valiant Roamer Robot. This task was included to identify the differences, if any, in strategies used during tasks with and without the Valiant Roamer Robot.
Mon	**9.30-10.30**	**The children worked on their own to complete this task (approx. 30 minutes each):**
Tue	**9.30-10.30**	**Design, Print and Build: Draw a picture on a piece of paper and use the software program 'Millies Maths House' to create the same picture. Print out the picture and replicate the design using wooden blocks. The children then discuss the differences and similarities between the three pieces of work.**
Wed	**9.30-10.30**	
Thur	**9.30-10.30**	

Table 2: Problem-Solving Strategies (Pre & Post-robotic)
Adam : Reflective Case

Observable Behaviours	Pre-robotic	Post-robotic
Problem Recognition		
define the goal for themselves	**frequently**	**frequently**
work out a general plan of attack	**not observed**	**rarely**
Problem Solving - Planning		
selecting operations to perform	**not observed**	**occasionally**
sequencing operations - where to begin	**not observed**	**occasionally**
identifying potential obstacles/errors	**rarely**	**frequently**
predict results	**rarely**	**frequently**
Problem Solving - Action		
Task Persistence		
- keeps on task	**occasionally**	**frequently**
- flitting from task to task	**rarely**	**rarely**
- returns to the activity	**rarely**	**rarely**
- copes with task interruptions	**occasionally**	**frequently**
- socially orientated	**occasionally**	**occasionally**
Locus of Resources		
Materials (Input)		
- experiments with given resources	**frequently**	**frequently**
- seeks additional resources to solve a problem	**occasionally**	**frequently**
Teacher (Input)		
- asks for help	**rarely**	**occasionally**
- responds to adult's prompt	**rarely**	**frequently**
Peers (Input)		
- asks for help from peers	**rarely**	**rarely**
- accepts help from peers	**rarely**	**rarely**
Peers (Output)		
- helps others	**occasionally**	**frequently**
- response to a request for assistance	**occasionally**	**frequently**
Problem Solving - Monitoring/Evaluation		
reasonableness of result	**rarely**	**frequently**
spotting errors	**rarely**	**frequently**
attempts to correct errors	**rarely**	**frequently**
evaluating the appropriateness of the method	**rarely**	**occasionally**

Joseph (impulsive) typified the dual nature of young children's emerging learning strategies. For example, throughout the pre- and post-robotic observational period they clearly demonstrated patterns of typical non-strategic behaviours. Although the children generally exhibited these non-strategic behaviours, towards the later part of the post-robotic period some of their behaviours reflected strategic patterns. For instance Kevin began to seek help from the teacher and respond positively to the feedback that was given. He also began to show signs of becoming an independent learner as evidenced by his self correction and spotting of errors. Sandra also demonstrated changes in behaviour, but on a less noticeable level. She exhibited signs of becoming a more independent learner through self correction. Joseph was able to cope with task interruptions and stayed on task to a greater extent than observed in the earlier phase. As with Kevin he also showed evidence of becoming a more independent learner.

It appeared that one of the reasons for this apparent shift in learning pattern was related to the nature of the task at hand and another related to the fact that they had time to model the strategies that were encouraged by the teacher. Also the tasks involving the programming of the robotic device appeared to encourage the use of certain strategic behaviours that didn't appear during the earlier tasks. This indicated that the Valiant Roamer Robot can encourage the use of strategic learning approaches, which in turn promotes a metacognitive environment. Trinidad (1992) also found evidence to support similar findings i.e. that children are encouraged to use strategic learning approaches when using different types of software on a computer.

Within the one task, young children can exhibit both types of learning behaviours (strategic and non-strategic).

A good example of this was demonstrated by Adam, the case study child who was categorized as being reflective according to his MFFT score. During the task of designing, creating, and building a design of their choice(see task week 6), Adam began by attempting to explain the goal of the exercise to the researcher. He then drew a picture of a robot and began to design the picture on the screen. While the researcher was attending to another child he was seen screwing up his drawing and throwing it in the bin. When asked, "why did you do that?" He replied, "It was too hard. I'm going to do something else!". However, prior to beginning his next design he looked at the shapes on the screen and then decided to draw a dog. He then continued to stay on task. His printout reflected a picture of the dog he had designed and then successfully built using the wooden blocks. He was able to talk through the process of his planning steps and compare the different representations of the dog. Thus different aspects of Adam's behaviour sometimes reflected those of a strategic learner and other times those of a non-strategic learner. When he found the robot too difficult to represent on the computer screen and screwed it up he had demonstrated a non-strategic approach to learning. If he had sought help from his peers or teacher, or persisted with the task, perhaps this would have suggested the use of a strategic approach. On the other hand, planning his second design around the shapes on the screen, staying on task, and evaluating and comparing the different designs, clearly reflected a strategic approach to learning. Therefore, within this one overall task

Adam exhibited both types of learning behaviour.

During this same activity Alice, who opted to do the task twice, with a different design, also demonstrated this dual learning approach within the one task. Alice began by drawing a picture of a dog. She then selected the shapes she needed and placed them on the side of the screen. After using the rectangles for the body and placing it in the centre of the screen she stopped and said, “I need some help.” Joel who was close by suggested that she use the circle for the head and the rectangle for the tail. She then placed these on the body accordingly. When this was done she commented, “I can’t build this, the tail will fall off.” She realised that she would not be able to build the dog the same as the picture on the screen. She then moved away from the computer and proceeded to go outside. Alice began by being task oriented, adequately planning her design and asking for help when she was having difficulty - all behaviours reflecting those of a strategic approach to learning. This type of approach changed however, when she appeared to become bored with the task due to its difficulty.

There appeared to be no relationship between the age of the child and the type of learning strategy they generally used during the pre and post-robotic phase of this study. In fact, the eldest (Sandra), and the youngest (Joseph) child were both classified impulsive due to their MFFT scores and were considered to exhibit generally non-strategic learning behaviours. In similar vein at the same age, Kevin’s (slow/inaccurate) behaviour generally reflected those of a non-strategic learner, whereas Alice’s (fast/accurate) behaviour was generally considered to be strategic in nature.

Teacher scaffolding is an important requirement to assist young children in the development of effective problem-solving strategies and metacognitive skills.

The term scaffolding has been used to describe the assistance an adult or peer gives when the child is having difficulty completing a given task. Scaffolding, as outlined by Maddux, LaMont & Willis (1997), is a structured approach and comprising various components. Even though many of these components (ie. joint problem-solving, warmth and responsiveness and promoting self-regulation) were obvious throughout some of the sessions with the case study children it was not the intention of the researcher to measure and evaluate this dimension. What did become evident however, was the importance of the support structure provided by the teacher.

One such event occurred when case study student, Sandra, had just completed her building and was asked by the researcher:

“Is your picture the same as your building?”

> She responded by nodding her head. She was then asked to explain how it was the same. Sandra began pointing to individual shapes that were part of her design and then pointing to the corresponding block found imp her building. Half way through this process she realised that there were some blocks missing from her building that were represented in her design. She then modified the building according to the design (as close as she could possibly get) and said, “Now it is the same.”
>
> (Week 7)

Without this support from the teacher this child would most likely have remained at the same stage of the problem task. This need for teacher support seems especially important for those children classified as impulsive or slow/inaccurate, who were observed not seeking help from others. Being able to help the child move from what they can do with an adult or peer, to what they can do on their own, is an important transfer task. This fine line of transition is referred to by Clay (1991) as the ‘cutting edge of learning’.

Noticeable differences in student’s choice of learning strategy are visible only after some quality time and input by the teacher.

In a preprimary setting children are aware of the time limitations placed upon them. There is always the urgency of completing an activity, whether it be cutting out an elephant or eating lunch before the bell rings. Many instances throughout this study reflect the notion that learning has its greatest potential when a child can browse around in a problem environment, exploring and fiddling with the bits and pieces, pressing buttons and turning knobs, and always taking their time. Given the opportunity, the case-study children were seen to be content to explore constructively and play with the Valiant Roamer Robot. Like Papert (1980), Hofmann (1986) and Davidson & Wright (1994), this research suggests that children learn best when they are able to explore and control their own environment.

Providing children with adequate time is not the only factor that appears to encourage and foster a metacognitive environment. One of the key factors that contributes positively to such an environment is the quality of the adult-child interaction in a problem-solving environment. Evidence from this study indicates that only after teacher input were real changes noticeable. For example, during the collection of the base-line data, which included observing the case study children during routine tasks as well as setting a particular problem-solving task in weeks 1 and 2, there was very little teacher input. The children were given a task and observed. During the set task (building a house for the giraffe) the children were given very little prompting or guidance. They were simply asked to explain what they had to do, what they were doing if it wasn’t obvious, and encouraged to evaluate their house when complete. Whereas, once the Valiant Roamer Robot was introduced there appeared to be much more structure within sessions, and more guidance provided from the teacher. This structure and guidance was essential if the children were required to master the basic programming steps necessary for the Valiant Roamer Robot to move. Even after the children had mastered the basic commands, teacher input was still essential if progress was to be made. All of the children in the post-robotic phase compared to the pre-robotic phase were observed with higher frequencies of many of the positive problem-solving strategies outlined in the Problem-Solving Observational Instrument.

Teachers can help children acquire basic problem-solving skills by providing them with quality time and input. These basic skills provide children with sound foundations essential for solving future problems. Young children need to be shown and made aware of the problem-solving strategies they need to model in order to effectively develop their cognitive 'toolkit'.

Providing young children with a model that encourages them to follow a process that enables them to identify a problem, plan a solution, implement the plan, evaluate the outcome, and then modify it accordingly must be of value to a child beginning to develop effective problem-solving skills.

Young children in the 4-5 year old age group find introspection difficult.

Evidence from this study suggests that children seldom reflect on their learning experiences with teachers and peers while immersed in problem-solving situations. These observations find support from other researchers (Flavell, Green & Flavell, 1995; Harris, 1995). This study recognized that children often resolve a problem without really understanding how their goal was achieved. The findings of this study suggest that even when prompted by the teacher, young children find it difficult to report what they have been thinking. For example: During the task of building the bridge for the Valiant Roamer Robot to pass under, Adam was unable to explain why he felt the correct length was 6, as he had previously suggested. During the same task Sandra, when questioned, "how do you know it will be 5?", didn't reply.

Perhaps young children find introspection difficult because they haven't been exposed to the types of questions and responses that model their own or some one else's thought processes or reflections. The present researcher acknowledges that this is an area that if acted upon, may have revealed more useful information for the study. One possible explanation is that young children are hesitant to respond to questions which are reflective in nature because they don't want to be seen as incorrect. Young children have a strong sense of right and wrong, and perhaps questions that ask them how they come to know something may confuse them. Even the two case study children who were classified as reflective according to their MFFT score, and demonstrated behaviours that reflected a strategic approach to learning throughout the pre and post-robotic phase of this study, appeared confused or unsure when presented with reflective type questions. For example:

Joel used the magnetic cards to show the children the set procedure required to program the robot. I asked him to explain the functions of the different keys. He was able to do this well. He then programmed the robot to go forward, however, he used a very large number. He looked up at me and quickly ran to the robot and turned it off. When questioned, "what happened Joel?" There was no response and Joel continued to program the robot again. I asked again, "what did you press Joel?" He continued to program the robot and again pressed a large number. As the robot moved forward I again asked, "where do you think it will end up this time?" Joel looked at me, however still didn't respond and quickly focused on the movements of the robot. The robot continued to go into the block corner until Joel ran to stop it from hitting the wall. "What did you press this time Joel?" He was just about to begin again when I stopped him. "What did you press?" He then looked at me confused and was unable to respond. (Week 5)

Adam was working with his group and said that he was going to make the robot reach the edge of the mat. He pressed the number 8 and the robot stopped just prior to the edge of the mat. I asked "How did you know to press 8 Adam?" He responded, "I just did. " (Week 5)

Some have argued (Wilde-Astington, 1995) that introspection in young children is first experienced when they begin to question their own thoughts. Perhaps the teacher or adult can promote such introspection in young children by asking them more often to explain in their own words what their brain is telling them.

Exposure to a programming language via a computer driven robot operating with Logo-like commands, can positively affect children's problem-solving strategies.

Riding & Powell (1987) and Orabuchi (1993) have suggested that computer programs which encourage children to solve problems can provide positive motivation for children as young as kindergarteners to make choices and decisions, to alter their strategies, to persist at tasks, and to score higher on tests of critical thinking and problem-solving. This study has produced evidence to support such findings. The Valiant Roamer Robot proved to be a highly motivating and non-threatening device for young children at this pre-primary stage.

Pea cited in Underwood & Underwood (1990) claimed that Logo was "cognitively complex beyond its early steps, and quite difficult to learn without instructional guidance." This can also be said of the Valiant Roamer Robot. Even though the programming element of the Valiant Roamer Robot allows children to break down a given task into small specific steps, they still need to be taught these initial basic steps. To help the case study children grasp these basic skills specifically designed materials were used, such as charts and magnetic cards. The charts outlined clearly the steps required for certain procedures. The magnetic cards representing commands enabled and encouraged the children in this study to plan their procedures, as well as monitor and evaluate their procedures along the way. The magnetic cards also provided an excellent source of evaluation for the teacher. The programming language associated with the Valiant Roamer Robot also provided the children with the opportunity to make choices and decisions, as well as alter their problem-solving strategies.

The Valiant Roamer Robot proved to be a tool that provides an open-ended environment not unlike word processing packages, databases, and Logo. All of these tools promote the development of a child's cognitive 'toolkit'. This study has also shown that many of the benefits associated with introducing computers in the early childhood classroom can also be attained through the introduction of a robotic device such as the Valiant Roamer Robot. There is evidence from this study that such technological environments can also encourage cognitive development, social interactions, language, and fine motor skills.

Trinidad (1992) questioned the positive outcomes associated with the Logo programming language being attributed to the support structure provided by the teacher as well as the teacher child ratio. One could also say the same of this study, that perhaps the teacher scaffolding contributed to the increase of the strategic learning behaviours displayed by the children and not the Valiant Roamer Robot itself. Similarly, the case study children's maturity over a six week period could also be another factor contributing to this increase. As in Williams's (1992) study, the introduction of the Valiant Roamer Robot positively enhanced the case study children's metacognitive problem-solving strategies over the observational period. The use of robotics contributes to a metacognitive environment which promotes and allows for an awareness of, and reflection on, young children's cognitive processes and products.

"One could also say the same of this study, that perhaps the teacher scaffolding contributed to the increase of the strategic learning behaviours displayed by the children and not the Valiant Roamer Robot itself."

The teaching of problem-solving skills and associated social skills are enhanced in a robotic/computer microworld.

Technology uptake by young children is largely a social phenomenon and needs to be promoted primarily within a social context.

This study has provided evidence that the computer robotic microworld introduced into this classroom through the Valiant Roamer Robot provided a range of experiences which allowed the students to practise independent and group learning strategies as well as beginning the process of reflecting on their thinking. The positive effect on their motivation and general attitude towards learning was another important outcome noted in association with this robotic microworld.

It has been suggested that awareness of a student's own thinking and self-regulatory activities can only develop through social interactions with other students (Davidson, 1989; Ryba, 1991). Similarly, Wertsch (1985) advocates the importance of group work in a metacognitive environment, and encourages the idea that teachers need to relinquish some control in the classroom for this to occur. It is through such communication with others that children progressively learn how to understand their own cognitive processes and control their own learning. The Valiant Roamer Robot environment encouraged such social interactions. On this point of social interaction, according to Nastasi and Clements (1993), young children prefer to seek help from their peers rather than their teacher. However, in this study their preferences on balance favoured rapport with their teacher rather than their peers. Some of the factors that perhaps contributed to this were, more exposure and access to the teacher, and the teacher as a new face, therefore a novelty.

Many of the observations made throughout this study suggest that in an age of technology, it is through relationships with others, and through joint activities and language, that children can begin to grasp true understanding and meaning.

Summary of Outcomes

- Depending on the type of task, children of this age (4-5yrs) can demonstrate behaviours associated with both 'strategic' and/or 'non strategic' learning strategies.
- Tasks involving the programming of the Valiant Roamer Robot appeared to encourage the use of certain strategic behaviours that didn't appear during the earlier tasks.
- Within the one task, young children can exhibit both types of learning behaviours (strategic and non-strategic).
- There appeared to be no relationship between the age of the child and the type of learning strategy they generally used during the pre and post-robotic phase of this study.
- Teacher scaffolding is an important requirement to assist young children in the development of effective problem-solving strategies and metacognitive skills.
- Noticeable differences in student's choice of learning strategy are visible only after some quality time and input by the teacher.
- Problem-solving strategies need to be actively taught.
- Young children in the 4-5 year old age group find introspection difficult.
- Children seldom reflect about their learning experiences with teachers and peers while immersed in a variety of problem-solving situations.
- Exposure to a programming language via a computer driven robot operating with Logo-like commands can positively affect children's problem-

solving strategies.

- The Valiant Roamer Robot proved to be a highly motivating and non-threatening device for young children at this preprimary stage.
- There was a noticeable difference in the problem-solving strategies used by the case study children during the pre-robotic phase and the post-robotic phase. All of the children in the post-robotic phase were observed with higher frequencies of many of the positive problem-solving strategies outlined in the Problem-Solving Observational Instrument. The type of behaviour appeared to reflect the type of task at hand, and on the level of teacher or peer scaffolding.
- The Valiant Roamer Robot positively enhanced the case study children's metacognitive problem-solving strategies over the observational period.
- The Valiant Roamer Robot environment encouraged social interactions.
- The case study children favoured rapport with their teacher rather than their peers. The novelty of the teacher and the greater exposure and access to the teacher may have influenced this outcome.

Final Comment

Teachers need not be fearful of new technologies and new technological processes. The well-established Design, Make and Appraise (DMA) approach being implemented in many of our schools, encourages those problem-solving strategies essential for the development of metacognitive abilities as outlined in this study. The use of the Valiant Roamer Robot proved to be a non-threatening, innovative and exciting way of introducing technology to young children - bearing in mind that as educators we are usually more interested in helping develop a process not the product. As teachers, we need to encourage our children to become active problem-solvers and processors of information, not just recipients of already produced solutions.

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