# LEGO Robotics: An authentic problem solving tool?

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## Abstract

With the current curriculum focus on correlating classroom problem solving lessons to real-world contexts, are LEGO robotics an effective problem solving tool? This present study was designed to investigate this question and to ascertain what problem solving strategies primary students engaged with when working with LEGO robotics and whether the students were able to effectively relate their problem solving strategies to real-world contexts. The qualitative study involved 23 Grade 6 students participating in robotics activities at a Brisbane primary school. The study included data collected from researcher observations of student problem solving discussions, collected software programs, and data from a student completed questionnaire. Results from the study indicated that the robotic activities assisted students to reflect on the problem solving decisions they made. The study also highlighted that the students were able to relate their problem solving strategies to real-world contexts. The study demonstrated that while LEGO robotics can be considered useful problem solving tools in the classroom, careful teacher scaffolding needs to be implemented in regards to correlating LEGO with authentic problem solving. Further research in regards to how teachers can best embed real-world contexts into effective robotics lessons is recommended.



## Key words

technology, LEGO robotics, problem solving, metacognition, reflection, authentic contexts.


## Introduction

The use of robotics within middle years' classrooms can help students to develop problem solving strategies while engaging them in exploring and understanding mathematics, science and technology concepts (Chambers & Carbonaro, 2003, Chambers, Carbonaro & Rex, 2007, Chambers, Carbonaro & Murray, 2008; Dillan, 1995; Norton, McRobbie & Ginns, 2007; Portz, 2002). Scaffolding knowledge construction using a guided inquiry instructional approach with robotics develops conceptual understanding, enhances critical thinking, and promotes higher-order learning in the domains of mathematics and science (Chambers, Carbonaro & Rex, 2007; Chambers, Carbonaro & Murray, 2008). Students immersing themselves in technology and designing curriculum, specifically through robot activities, facilitate teamwork, problem solving and critical thinking skills (Norton, McRobbie & Ginns, 2007). Using robotics activities not only encourages students to form successful communities of learning they also enable teachers to successfully integrate science, mathematics and technology domains. Teachers can create robotic learning activities in the classroom that are collaborative, creative and authentic (Dillon, 1995; Portz, 2002). Interacting with classroom technology is essential for today's learners in that digital materials are becoming increasingly common in daily environments. The use of digital technologies in the classroom allows students to understand the possibilities of transferring classroom technologies to other contexts (Barchi, Cagliari & Giacopini, 2002).

While previous studies have focused mainly on the mathematical and science concepts learnt by students when using robotics, including gear mechanics and motion (Chambers, Carbonaro & Murray, 2008), navigation and direction (Dillon, 1995; Portz, 2002) and ratio (Norton, McRobbie & Ginns, 2007), this study builds upon previous research by specifically focusing on the problem solving strategies students utilise while working with LEGO robotics, and their abilities to reflect on these strategies. For students, reflecting on their problem solving strategies is important in that their metacognitive beliefs, decisions and actions can be determinants of learning success or failure (Garofalo & Lester, 1985). Furthermore, the ability to reflect on and correlate problem solving strategies to authentic contexts can provide students with the confidence needed to successfully solve problems in authentic situations (Kramaski, Mevarech & Arami, 2002). For students, making authentic connections is imperative in that they are able to gain an understanding of 'how' and 'what' they have learned. When students understand the problems they have solved they are then able to correlate and communicate these understandings to problems encountered on a daily basis (Edwards-Leis, 2007)

The purpose of this study was to examine the correlation between middle year's students' problem solving strategies while engaged in a LEGO robotics activity and the abilities of those students to reflect on and relate their problem solving strategies to real-world authentic problem solving contexts. More specifically, the project sought to answer the following:

1. What problem solving strategies do middle years' students engage when utilising LEGO robotics as an educational tool?
2. Are middle years' students able to effectively relate problem solving strategies to other contexts?

## Literature Review

According to Papert (1993) when children learn to use computers and software in masterful ways, they often transfer this learning to other life realms. Papert's constructionism theory (1980, 1991) suggests that metacognitive skills are constructed through students as active builders of their own intellect, and that integrating computer technology into the specific problem solving realm can be a major determinant of real-world problem solving aptitude. Metacognition or “reflective intelligence” (Skemp, 1987) describes the active monitoring and consequent regulation of thought processes in regards to a specific objective or goal. Reflection is a powerful link between thought and action, which can supply information about outcomes and the effectiveness of the applied strategies when problem solving. Reflection allows learners to consider plans made prior to tasks, assess and adjust as they work, and revise and relate the problems to authentic contexts (Ertmer & Newby, 1996).

Problem solving uses an investigative approach to promote student awareness of their learning skills, performances and of their abilities to reflect on what they have learned. Problem based learning has been the focus of much research and with many curriculums now reflecting the need for greater problem solving strategies, teachers are now considering new ways to implement problem based learning into existing lessons. Acquiring problem solving skills is essential for students’ futures. While the teaching paradigm of teach, learn, practice and assess are common teaching methods employed by educators, this is not how problems arise in the real world (Peterson, 2004). Authentic problems are not usually provided with a way in which to generate an answer and as such there is a gap in how teaching methods encourage metacognitive awareness and how students relate this awareness to everyday problems. Teaching students to become metacognitively aware is not an easy task, however most curriculum advisors agree that problem solving is most effective when carefully scaffolded by educators (Pang, 2010).

With modern curriculum in Australia focusing heavily on ‘key competencies’ including problem solving strategies (Ashman, 2010; Le Metais, 2003), teachers need to actively correlate their problem based learning with authentic contexts. Authentic learning and assessment refers to learning opportunities that can be related to, and seen as, valuable outside the classroom (Lowrie & Smith, 2002). For students, making authentic connections is imperative in that they are able to gain an understanding of ‘how’ and ‘what’ they have learned. When students understand the problems they have solved they are then able to correlate and communicate these understandings to problems encountered on a daily basis (Edwards-Leis, 2007).

Authentic learning is meaningful to students and demands that they actively solve problems and reflect on how well they have achieved their objectives. However, whilst authentic problems are rich powerful learning tools, there is little research to demonstrate that teachers are effectively embedding authentic learning opportunities and encouraging students to reflect upon their use in relation to real-world contexts (Kramaski, Mevarech & Arami, 2002). The small but present existing body of knowledge suggests teachers find authentic tasks time consuming and their corresponding assessment complicated. Research has further demonstrated that students often have difficulty monitoring and reflecting on their learning, therefore it is not surprising that teachers are reluctant to teach authentic tasks and correlate them to real-world situations without the correct support of curriculum and educational tools (Kramaski, Mevarech & Arami, 2002).

LEGO robots as educational tools engage students in their own learning through active constructionist environments, which in turn promotes the development of higher thinking and problem solving skills, promoting student conceptualisation in meaningful authentic ways (Chambers, Carbanaro & Murray, 2008). With LEGO robotics, students are engaged in their learning and as such, they often gain critical thinking skills conducive to more comprehensive meaning making. Robotics can provide an authentic context for learning and offer technological literacy skills necessary for participation in a modern world. A study on problem solving by Barak and Zadok (2007) identified that students involved in robotics activities often utilise heuristics in the classroom (the processes in which problem solvers identify solution methods) based on their own life experiences. The heuristics used by students can then be capitalised on to strengthen and expand students’ real-world problem solving capabilities. LEGO robotics can be a useful tool in aiding student’s problem solving capabilities in the classroom (Barak & Zadok, 2007; Norton, McRobbie & Ginns, 2007) and a useful tool for curriculum based technology assessment (Edwards-Leis, 2007).

## Method

A descriptive qualitative case study method was used for this study to focus on identifying themes and connecting categories (Creswell, 2008). A qualitative case study approach acknowledges the subjective nature of data collection and interpretation especially in educational contexts where the boundary between the phenomenon and its context is often unclear (Yin, 1994). Following the principles of data collection proposed by Yin, data were collected from researcher observations regarding the groups problem solving, robot design, modifications, software programming and the two specific problem solving tasks.

The study involved two weeks of daily one-hour lessons and observations were recorded at the end of each of these lessons. The observations focused on what problem solving strategies the students used and how they were able to use the strategies to solve the robot race and maze problems, what connections students were making between the strategies used and real-world situations, and how they were reflecting on their problem solving. Data collection further comprised a short questionnaire undertaken by the students upon completion of the set problem tasks. The questionnaire was researcher created and based on the metacognitive studies of King (1991) and Schraw (2001) that use strategic questions to guide students' reflections on strategy during problem solving.

The students were asked:

1. How did you calculate the secret distance time for the robot?
2. Explain how you used your trial runs. What strategies did you use?
3. What strategies did you change during your trial runs?
4. What new strategies did you learn?
5. Where else in your life could you use these strategies?

The case study was conducted in a Grade 6 classroom within an outer Brisbane state primary school. The class consisted of 23 students (12 male and 11 female) with no prior robotics instruction, who were divided into 8 groups of 2-4 students of mixed mathematical, technological and problem solving abilities. Groups were assembled prior to the study by the classroom teacher who selected the participants based on the abilities demonstrated by the students throughout the school year. Each team consisted of two to four students; two groups comprised all male students, three groups were all female and the remaining groups had both male and female members (see Table 1). The eight robots were called Ironbot, TANK, Hamilton, Wheely, M.O.E.Bot, Nemo, JJ and Yummy, as shown in Table 1. Each group was specifically formed with differing genders and abilities to allow for dissimilar design and problem solving strategies to emerge and evolve.

During the two weeks of lessons students were shown the basic LEGO robotics building and programming procedures and then encouraged to actively make design modifications and program their robots. The introductory lesson of the study consisted of 15 minutes of direct instruction in which the activity was introduced and the robots, software, and problem solving activities were discussed. To complete the first lesson student groups were each given a LEGO robot kit and asked to build their basic robots following the included LEGO instruction booklet. By following the instruction booklet, most groups were able to build their robot successfully with minimal problems. The research was specifically scaffolded in this way so students were able to gain success at the initial building stage and also to provide a common base from which students were able to modify their robots for specific tasks in later stages if required by the group.

The second lesson involved a 10 minute instruction in which students were shown how to use the LEGO Mindstorms software program to direct their robots. The Mindstorms software program has an easy to use interface in which students choose a function tile from the selection (for example, a movement tile) and simply drag the tile to the screen, then apply simple instructions to the tile for the robot to perform the selected function in a particular way (for example, move forwards for 3 seconds). The single tile program for the Robot Race (see Figure 1) allowed the robots to move forward and then stop. Once students had programmed their initial movement the robots were then connected to the computer by a Universal Serial Bus (USB) and the program was downloaded directly to each

| Robot Groups | | | |
|---|---|---|---|
| Robot names | Male | Female | Total |
| Ironbot | 3 | 1 | 4 |
| TANK | 3 | – | 3 |
| Hamliton | 1 | 1 | 2 |
| Wheely | 2 | 1 | 3 |
| M.O.E.Bot | 3 | – | 3 |
| Nemo | – | 3 | 3 |
| JJ | – | 2 | 2 |
| Yummy | – | 3 | 3 |
| Totals | 12 | 11 | 23 |

*Table 1*

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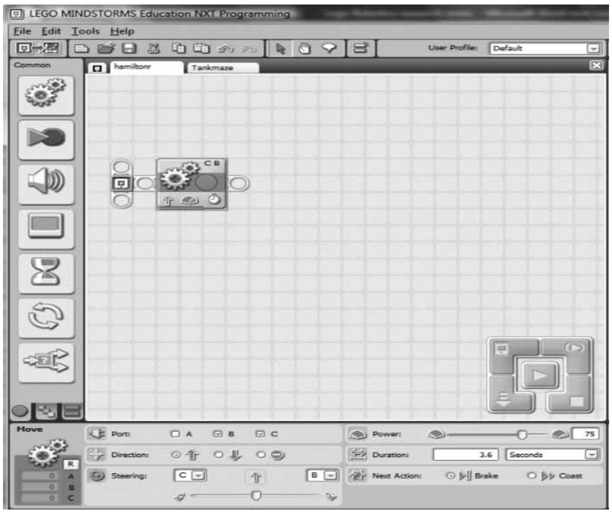


*Figure 1. Mindstorms software program for the Robot Race demonstrating one tile representing a forwards movement for 3.6 seconds.*

robot allowing the robots to follow the software program instructions. Students utilised the remaining lesson time to expand upon and practice robot programming including opening and adjusting the saved robot files and programming forwards movements. The groups had multiple attempts at programming their robots and during their trial runs made necessary design and software changes to ensure that their robot was running effectively.

### Problem 1 'The Race'

The introduction of the Robot Race was the focus for lesson three. Students were informed of the race problem and were given data collection sheets to start collecting data for the upcoming race. Students fixed a 150cm tape measure to the ground and used the data collection sheet consisting of two columns, where they could record the time programmed, and the distance travelled. Students were asked to trial a number of different times and to record the distance the robot travelled.

After students had conducted a number of trial runs with their robot they were presented with the problem of finding the 'secret' distance. Five minutes prior to the race, the student groups were informed of the secret distance of 117cm. Groups were advised that the race winner would be the robot that finished closest to the LEGO figure, placed on the tape measure at 117cm. Each group had 5 minutes to strategise the time they would program for the race, program their robot, and place their robot on the starting line. Students were further informed that trials runs and robot design were dependent upon their group's decisions; however groups needed to be strategic with their programming in order to finish closest to the secret distance (see Figure 2).

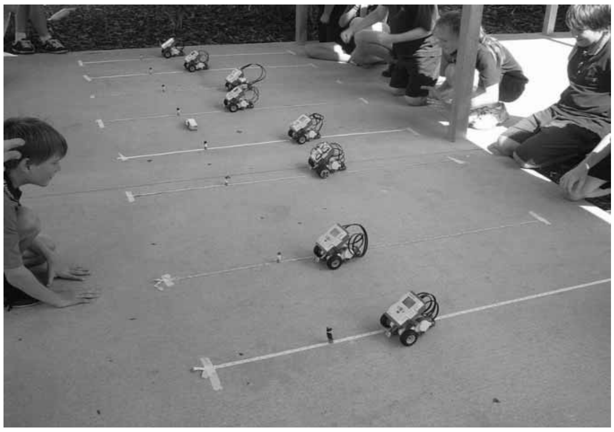

*Figure 2. The Robot Race*

### Problem 2 'The Maze'

The Maze was introduced in lesson six and students were able to redesign their robots for optimum performance if they desired. The Maze activity differed from the Robot Race in that it required the students to learn new software programming including navigating directions and turns, and required the use of a tile sequence instead of a singular tile (see Figure 3). Students groups were again given time to learn new programming techniques including turning with degrees or rotations, and navigating the robot in reverse. Groups spent the remaining lessons redesigning the robot and their robot's program and navigating their robots through the maze.

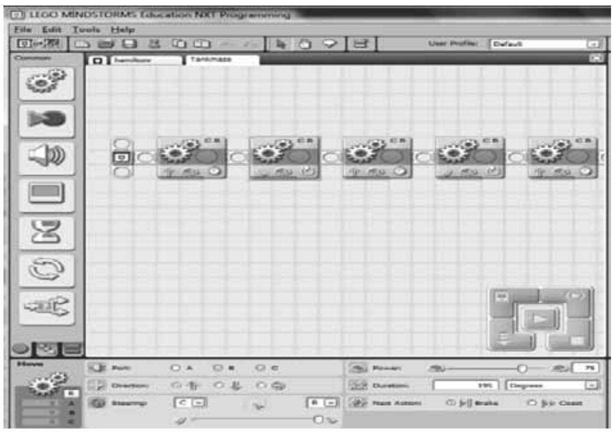


*Figure 3. Mindstorms software Maze program demonstrating a series of movement tiles programmed to navigate directions through the maze.*

Teams were asked to successfully navigate their robots through the maze, cross the finish line, and return to the starting place without touching the maze outline (see Figure 4). To do this, the robots began on the start line, travelled forward, turned right, travelled forward, turned left and crossed the finish line. Students then programmed their robots to either turn 180° and travel back through the maze in a forwards motion or simply return back through the maze in a reverse motion. For each directional change and forwards movement, a separate tile was programmed to form the software program sequence needed to successfully complete the task.

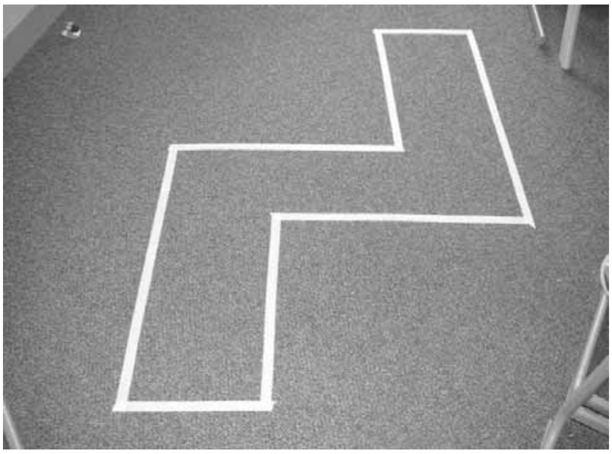

*Figure 4. The Maze*

## Results

The analysis of the data incorporated a constant comparison method as recommended by Strauss and Corbin (1998). Constant comparison relies on the emergence of categories from the data analysis (Huberman & Miles, 2002). Several major themes arose from the study that focused on students' problem solving and authentic reflection skills. Estimation and looking for number patterns were the most common problem solving strategies used by the students in the initial stages of programming. This was closely followed by trial and error. When correlating their problem solving strategies to real-world contexts, transport and general careers were the most prominent themes. These themes are further explored and presented in this results section. In order to address the research questions this section will present the results in two sections. The first section addresses the problem solving strategies students use when working with LEGO and the second section addresses the relation of classroom problem solving to authentic settings.

*Section 1- What problem solving strategies do middle years' students engage when utilising LEGO robotics as an educational tool?*

To assess the problem solving strategies of the students, the class was provided with the race and maze inquiry tasks, which required them to produce a solution. These tasks included robot design and construction, and software programming. Although the students had little robotics knowledge prior to the activities, as robotics was new to the school curriculum, they quickly became proficient at robot building and programming. Of the eight groups in the study, most groups were able to successfully construct the robots unaided, while two groups required some instruction at this stage, for example, one group had difficulty attaching the robot wheels while the other group struggled with building the wheel base back to front.

Upon completion of the robot construction, the researcher observed that two of the completed robots had incorrect wheel assemblies. These two particular groups moved to the programming stage and soon realised that their robot construction was causing some concern with their robot's running proficiency during their trial runs. Although these groups found specific building areas difficult, such as wheel construction and attachment, they were able to distinguish within a short timeframe that their robot construction would need adjustment. Furthermore, each group was quick to locate the source of the problem and make the necessary modifications to their robot.

In the initial programming session, once each group had successfully completed programming their robots to move forward for a certain number of seconds, most group members were keen to have their turn programming the robot. During this initial stage if the students made a mistake with their programming they seemed hesitant to seek their own solutions and relied on instructor help. It was observed that as their efficacy increased, students began making strategic changes to the software programs and robot designs. At this initial stage of programming, groups were also invited to name their robot, program their robot to move forward, and accordingly save their program file. It was noted by the researcher during observations that naming the robots gave the groups a high sense of robot ownership and pride, and encouraged group togetherness.

Once groups had constructed and successfully navigated their robots in a forward movement, students began collecting data to compete in the race. The class was informed of the race problem and groups were supplied with the task tools (data collection sheet, tape measure and masking tape). Groups then began to collect the data they would need to calculate the secret distance. Results from the data collection sheets showed that the groups had tested from 1cm to 152cm (the beginning and end of the tape measure) to ensure that their robot would finish somewhere within the length of the tape measure.

The initial time programmed and used for each group caused their robots to move correctly along the tape measure, however most robots continued to travel for some distance after the end of the tape measure. All groups were quick to note that the time programmed (8+ seconds) was too high and adjusted their programming accordingly. On the first day of trial runs while groups were programming their robots to stay within the tape measure length (152cm) it was noted through observations that the groups were not correlating the trial runs and data collection with the race aim. On the second day of trial runs and as robot programming efficacy began to increase, groups began to think strategically about how their trial runs would affect their robots race performance. Groups that were initially programming using random number selection began to select distances progressed from whole numbers (ranging from 1-6) to decimals numbers (ranging from 1.2-6.5) in order to get more precise measurements.

The winning robot (Ironbot) completed and won the race by touching the LEGO figure without knocking it over, while other groups' robots finished within 1cm of the 117cm target (see Figure 2). The race demonstrated that all groups were able to problem solve effectively and responses to the first two questions on the student questionnaire (see Table 1) showed that the groups used a range of methods including estimation, addition and/or subtraction, division trial and others, including trial and error, to calculate the secret distance time.

| Question | Responses |
|---|---|
| 1. How did you calculate the secret distance time for the robot? | Estimation and rounding off (40%) |
| | Addition and/or subtraction (20%) |
| | Division (20%) |
| | Others: e.g. trial and error, measurement, software programming (20%) |
| 2. Explain how you used your trial runs. What strategies did you use? | Strategic number patterns (50%) |
| | Trial and error (20%) |
| | Others: e.g. robot design, random trials (30%) |

*Table 1. Responses to Questions One and Two on the Student Questionnaire*

| Question | Responses |
|---|---|
| 3. What strategies did you change during your trial runs? | Software programming changes (45%) |
| | Numerous trial runs (30%) |
| | Change in robot design (20%) |
| | Other: e.g. no changes (5%) |
| 4. What new strategies did you learn? | Software and programming (55%) |
| | Robot design (50%) |
| | Mathematical strategies (20%) |
| | Team collaboration (10%) |

*Table 2. Responses to Question Three and Four on the Student Questionnaire*

Although efficacy for robot programming had increased during the robot race, the introduction of new programming techniques for the maze caused some concern amongst the students. Students began to feel as though adding extra tiles may have been too difficult with one student stating "I don't think we can do this, it looks too hard", however within a short timeframe all groups had managed to use a programmed sequence of at least three tiles. As noted with the original robot race, as efficacy for the maze developed during the trial runs, so did the groups problem solving abilities. As students' confidence in their robotics abilities heightened, groups were actively seeking solutions to the problems that were arising (overturning/under turning, and too much/not enough distance, and software programming difficulties) independently. For example, Team JJ had initial difficulty with overturning, however through changing the turning degrees a number of times they were able to effectively turn for the remainder of the maze. Students identified strategies they had used and changes they had made during their trial runs including software programming changes, robot design, mathematical strategies, and teamwork (see Table 2).

Programming efficacy elevated when students began to question the efficiency of their robot design; students were offered the choice of redesigning their robots as well as their robot's program to meet the group's objective. While some groups were strategic and maintained the basic design citing reasons such as "the group doesn't want to waste race time rebuilding" and "we know how our robot's distance works so why change it?" others (mainly male dominated groups) were more concerned with the robot aesthetics. Of the groups redesigning their robots, only one group (M.O.E.Bot) was able to provide a strategic reason for rebuilding, with one group member stating: “we’ve added extra wheels for greater stability”. It was noted that groups who made robot design changes not conducive to race performance reflected on the robots performance after a few trail runs and readjusted their new design or reverted to the basic design.

Groups progressed through programming and navigating the maze and became quickly adept at making the necessary changes to complete the race without instruction. The first team to successfully navigate the maze (Wheely) did so with little instructor help after the original programming help. The next three teams completed the maze in quick succession and the remaining groups were also able to complete the maze task.

*Section 2 – Are middle years’ students able to effectively relate problem solving strategies to other contexts?*

The student groups were able to effectively identify and discuss the activity learning objectives including robot design and construction, software programming, and mathematical strategies articulately. The groups initially struggled to identify the problem solving strategies within the activities, however, after the researchers discussed examples of the problem solving skills students had used (for example redesigning their robots for better performance, or a particular mathematics skill), students were able to make the connections from the activities to real-world contexts. Few students were able to discuss the actual problem solving skills they had used in the activities and their correlations to authentic problem solving without this prompting. However, each group was confident that if asked to participate in a different LEGO problem solving activity, they would attempt the task with confidence.

The prominent theme found within the student groups when relating LEGO robotics to authentic contexts was that of transportation (see Table 3). Students identified that being able to calculate the amount of time it would take a vehicle to travel a certain distance could impact on their travel time. Students further recognised that the speed in which the vehicle travelled, and the type of vehicle being used (for example bus, car, train), would also impact on travelling time. Through working with the robotics, the students felt that they would be able to calculate the times needed to travel for certain distances at particular speeds, therefore problem solving travel departure and destination arrival times.

| Question | Responses |
|---|---|
| 5. Where else in your life could you use these strategies? | Transport/driving (45%) |
| | General future: shopkeeping, building industry, programming household and work equipment (45%) |
| | Robotic careers (20%) |
| | Maths/science careers (10%) |
| | Secondary school or university (10%) |
| | ICT careers (10%) |

*Table 3. Responses to Question Five on the Student Questionnaire*

Another theme the study identified was the correlation between problem solving with LEGO and future careers. While a small percentage of students discussed specific mathematics, Information and Communication Technology (ICT) and robotics careers, other students were able to relate the problem solving skills used in the LEGO activities to more general ideas including monetary calculations (for example shopkeeping/retail careers), measurement (building industry), and computer programming (household and work equipment). These students were able to identify the correlations between the LEGO problem solving activities and authentic problem solving strategies by relating the problem solving skills used in the activities to future applications.

## Discussion

This study sought to identify the problem solving strategies students use while working with LEGO robotics and to examine if they were able to effectively reflect on and relate these problem solving strategies to authentic situations. The analysis of the results including task participation, student questionnaires and researcher observations indicate that LEGO robotic programs allow students to analyse and reflect on the decisions they make in regards to the problem solving involved in robot design and programming. Furthermore, students are able to design, program and problem solve, and with prompting, are able to relate problem solving strategies to authentic contexts within a certain level. The discussion will accordingly focus on students’ problem solving strategies when using LEGO robotics and relating problem solving to authentic contexts.

When students engage in robot design/software programming, and make modifications in repeated processes with the aim of solving a specific problem, then they are reflecting during the action (Chambers, Carbonaro & Rex, 2007). Throughout both activities, each group was able to actively monitor, reflect, and adjust their processes in regards to strategically solving the problems. As students efficacy with the robotics heightened, so did their confidence in their problem solving abilities, and accordingly their metacognitive skills increased. Metacognition is necessary for students to gain deeper understandings of how tasks are performed (Garofalo & Lester, 1985; Schraw, 1998) and therefore to reflect on how each problem was solved. Students were able to successfully identify problems, negotiate modifications to design and programming, and implement the necessary changes to complete the set activities with their robots. The main strategies students in this study used to problem solve designing and programming the LEGO robotic activities were estimation and trial and error, both of which proved effective in this particular situation.

Although students successfully problem solved, the students may have performed differently with more supportive problem scaffolding incorporated into the lessons (Chambers & Carbonaro, 2003). As the research sought to identify the problem solving strategies the students used, they were given no problem solving strategies or scaffolding from which to build strategies upon. This decision was made on the basis that the students' problem solving decisions may well have been influenced by the scaffolding method implemented, leading to an incorrect result. While students were still able to problem solve effectively, the decision to provide no problem solving strategies or scaffolding did have some impact on the students' abilities to reflect on their problem solving strategies.

The student questionnaires and researcher observations were used to assess if the students were able to correlate the problem solving LEGO activities to authentic contexts. The study found that although most students were able to identify basic relationships, some students had difficulty recognising the connections without researcher prompting. The study further found that although the majority of students could formulate correlations, the themes identified demonstrated that the students only formed a basic understanding between LEGO problem solving and authentic contexts (Norton, McRobbie & Ginns, 2007), however, the students may only have formed basic understandings as they have yet to experience many authentic situations. Students may have been able to relate problem solving strategies to authentic situations with more definition if the problem solving itself was scaffolded to demonstrate ways in which problem solving strategies could be transferred to authentic contexts (Barak & Zadok, 2007).

Research suggests that students must have an understanding of the metacognitive and reflective practices they are utilising for authentic learning to be successful (Pang, 2010). While more research in this critical domain is warranted, factors for success in authentic learning include orienting students with the problem to be solved, guiding and providing reflective feedback whilst problem solving, and using effective methods to assess problem solving and their correlation to authentic reflection contexts (Peterson, 2004). However, while these strategies have proven effective, there is less known about how educators can effectively embed these strategies into modern classrooms for optimum results. With research suggesting teachers are inept to perform and assess authentic tasks in the classroom (Kramarski, Mevarech & Arami, 2002) further research is warranted. The study was limited by time and sample size. The study was further limited by minimal teacher problem solving scaffolding due to the nature of the study. Further research regarding how to relate problem solving strategies through LEGO robotics to authentic contexts is recommended.

## Conclusion

Creating conducive learning environments is a strategic process which focuses on the students' abilities to understand and reflect upon their own cognitive processes, and as such educators are faced with the question of how best to embed problem solving strategies into modern curriculum and pedagogies, and to further examine if students are correlating problem solving lessons within authentic settings. While this study demonstrated that LEGO robotics are effective tools for problem solving, it also established that problem solving strategies need to be carefully scaffolded in order for students to be able to relate their problem solving with LEGO robotics to authentic situations. With technological literacy and problem solving skills becoming essential for living in modern times, students must be provided with educational environments that will enhance these skills beyond the classroom. For problem solving to be successful in real-world situations, relating students' problem solving activities in the classroom to real-world contexts is of critical importance and as such more research must be undertaken in this important domain.

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