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Integrating robotics in primary school activities

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As teachers we know the importance of hands-on engagement in classroom activities. This is critical in tasks such as problem-solving because they draw upon learners' high-order thinking skills. The partnership between the hand and head transforms problem solving challenges from abstract into concrete entities which in turn simplifies problem-solving (Sennett, 2009). Such an approach also facilitates knowledge acquisition through knowledge "construction rather than instruction" (Rusk, Resnick and Cooke, 2009, p. 2). Papert (1991) proposed the idea of constructionism. He believed that individuals developed their knowledge as a result of their experiences – an idea extrapolated from Piaget's constructivist theory. Papert also suggested that by constructing products (e.g. models and artifacts) which have a personal significance, the learning can be assumed to be more meaningful (Rusk et al., 2009).

Models and artifacts have been used in classrooms for a long time, across a variety of subject areas, to simplify the complexity of certain concepts. Papert argued that "what you learn in the process of doing…sinks much deeper, its roots go deeper into the subsoil of the mind than anything anybody can tell you" (Madigan & Kroesch, 2011, p. 95). Robotics is one current example of using models and hands on challenges toward rigorous problem solving, and is becoming increasingly popular in teaching concepts in areas such as mathematics, science, and technology. Robots simplify the problem solving process because their use involves physical manipulations (Nersessian, 2009). The success of robotics in the learning environment has also been attributed to its: (a) appeal to the youth culture; (b) motivation and engagement value; (c) technical challenge factor; (d) social and problem-solving development options, and (e) alignment with academic disciplines (Grossman et al., 2002).

This article outlines the integration of robotics in two settings in a primary school. This initiative was part of an Australian Research Council project which was undertaken at this school. The article highlights how robotics was integrated in a technology unit in a Year 4 class. It also explains how it was embedded into an after-school program which catered for students from Years 5 to 7. From these experiences further possibilities of engaging with robotics are also discussed.

Robotics in a technology unit

Investigation, design, production, evaluation, and reflection are all important aspects of *Ways of working* of the technology *Essential Learnings* (Queensland Studies Authority, 2007). They use these "essential processes" to enable students to develop and demonstrate their *Knowledge and understanding*. Robotics can be used effectively to achieve these outcomes.

To explore this possibility further, a robotics unit was designed and implemented in a Year 4 class over 9 weeks. Each session lasted for 90 minutes. The LEGO Mindstorm kit was used for these activities. The teacher organised the twenty-four students into groups of 3-4. There was an open working area at the back of the classroom – this enabled groups to design, program and test their robots with ease. It also saved time because furniture did not have to be rearranged for the activities.

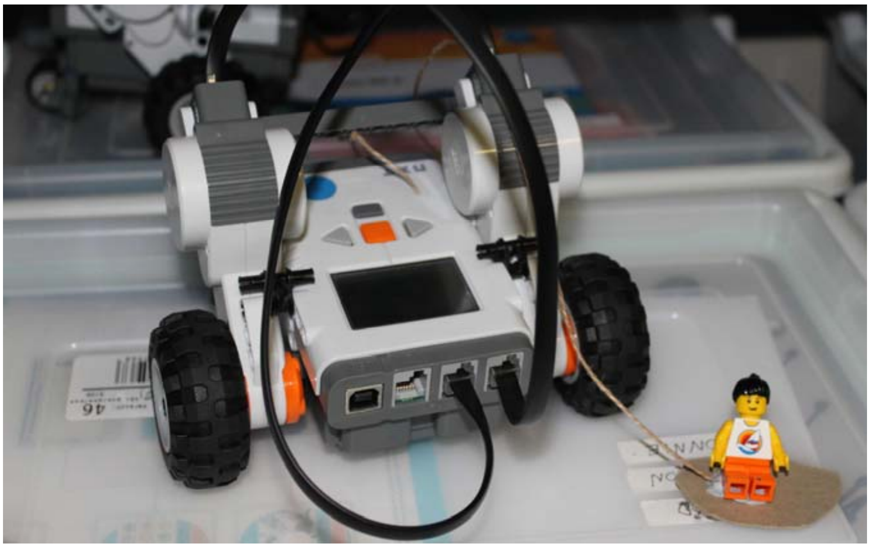

Figure 1: A LEGO robot

Each lesson generally started with a story or news item which was topical. For instance, when Google launched its driverless car last year, a news clip of this event set the scene for one of the weekly robotics activities. It served as an ideal opportunity to start a conversation with the students. Each student was also asked to complete a worksheet which was focused on this event. The questions on these sheets (e.g. Are driverless cars a good idea? Why?) not only enabled them to continue the discussion on this innovation, but also created opportunities for reading and writing print texts.

The challenges for the sessions were generally aligned with the stories. For instance, the challenge which followed Google's driverless car activity was that students had to program a robot to travel from Brisbane to a town or city in Western Australia. Google maps were used by the students to identify "their town". The complexity of the challenges increased progressively and culminated in an open-ended project. For this task, students had to rescue a miner (LEGO man) by using their robots. News clips from the Chilean mine rescue connected the students to this challenge. Through their engagement in this challenge, students were demonstrating their *Knowledge and understanding* on how *different ideas for designs and products are developed to meet the needs and wants of people* (Queensland Studies Authority, 2007).

In week 9, the students showcased their project solutions to their parents. Afterwards, the parents were invited to participate in a simple challenge themselves. For this task, the students acted as tutors and showed their parents how robots could be programmed and run in order to complete the challenge.

Robotics in the *MediaClub*

The *MediaClub* is run as an outside school program and is a part of this research project. The aim of this initiative is to investigate the opportunities that this increased capacity gained in an outside school setting, affords to young people inside school in their classroom and school learning contexts. Extracurricular or outside school programs generally aim to offer young people a different learning environment to that provided by the everyday classroom. Outside school programs such as *MediaClub* offer students an opportunity to engage with substantial content and skills in an informal learning context.

The robotics challenges for the students who engaged in the *MediaClub* robotics program were similar to those presented to Year 4 students. They were expected to find creative solutions to problems in a constructivist-learning environment using the LEGO NXT robots. However, the challenges were more complex – these students also had to use sensors in their robots.

The fifteen participants aged between nine and thirteen worked in groups of three to four, facilitated by an instructor and other support staff in weekly two hour sessions for eight weeks. Each week a challenge was presented to the participants. Over time, the complexity of these challenges increased as the level of scaffolding from staff deceased. Apart from hands-on problem-solving, the sessions also created numerous opportunities for collaborative learning and teamwork. Upon the completion of their tasks, the participants demonstrated their solutions to the problems to the rest of the group. This enabled opportunities for reflective feedback.

Students' reflections

Across all *Key Learning Areas*, *reflecting* is a critical step of *Ways of working*. In both these approaches, De Bono's six hats served as an effective framework to immerse students in the reflection stage (De Bono, 1999). The white hat question - *What was this challenge about?* gave an idea of whether participants' understood what the challenge was about. The green hat question - *Draw a diagram to show how you tackled this challenge* enabled participants to demonstrate their idea pictorially with some text. The yellow and black hat questions - *You had an idea on how you could tackle the challenge. What was good about your idea?* and *What was something about your idea that did not work the way you had planned?* enabled the participants to critically reflect on the successes and failures of their ideas. Perhaps the most significant questions were the blue and red hat questions - *What did you learn from this challenge?* and *If you did this challenge again, how will you change your idea?* These reflections were completed on a worksheet. For the Year 4 students, it served as good evidence for assessment.

Findings and future directions

In-class observations, student and teacher interviews have re-iterated the value of robotics as an education tool in classrooms. Some of these benefits have also been identified in previous studies (e.g. see for example Grossman et al., 2002). Intrinsic motivation is one of the most significant benefits of using this technology in classrooms. A common response of students is that they find robotics fun and challenging. By designing and appropriately scaffolding challenges with a moderate level of difficulty, students tend to get hooked to the task. Sometimes this can occur for extended periods. By programing and running a robot, students get instant feedback on the progress they have made in tackling a challenge. Engaging in the *technology practice cycle* (Queensland Studies Authority, 2003) occurs effectively because designing/re-designing, building/re-building, programming/re-programming, and testing/re-testing a robot is easily achieved.

Through hands-on engagement students are not only solving problems but also finding new ones and as a consequence constructing their own knowledge (Sennett, 2009). They develop their own strategies in acquiring this knowledge. Situating these challenges in a real life context further enhances its value.

Teamwork and learning collaboratively is another significant benefit of using this technology. Teamwork enables students to pool their ideas and knowledge in solving a challenge. They also develop their own strategies as their teams go through the stages of forming, storming, norming, and performing (Tuckerman, 1965). Seeing how other teams solve their problems demonstrates that there is more than one way to tackle a challenge.

Robotics competitions such as the FIRST LEGO League (http://www.firstlegoleague.org/) and RoboCup (http://www.robocup.org/) create opportunities for schools to take their students to the next level. The popularity of robotics and competitions such as these is growing globally. They work to encourage students to perform outside their comfort zones.

One of Albert Einstein's famous quotes is "It's not that I'm so smart, it's just that I stay with problems longer". As teachers, we need tools and strategies which can engage our students. Robotics may be one of the feasible options to achieve this goal.

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