STORYTELLING AND ICONOGRAPHY IN PROGRAMMING LEGO® ROBOTICS: RURAL AND REMOTE APPLICATIONS

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Abstract

A pilot project was developed to investigate the value of integrating storytelling and iconography into a robotics teaching program. The program was delivered to students in rural or remote areas with little or no previous experience of robotics and programming. The purpose of the implementation was to see if the integration of iconography and storytelling in the initial phase of a robotics program could assist development of programming skills in icon-based programming languages like LEGO® Mindstorms® in P-7 schools. The project was conducted in partnership between the Department of Education Queensland, Cairns State High School; LEGO International and the Royal Flying Doctor Service (RFDS) of Australia. The evaluation identified that integrating storytelling and iconography has the potential to improve student engagement and basic programming skills as it provides connectedness to the learners’ personal experiences and provides a mechanism to improve icon interpretation and application.

Introduction

Storytelling and iconography are central components of many cultures. Robotics teaching programs are delivered in some schools and focus primarily on developing students’ engineering, programming and problem solving skills. Recognition of the cultural importance of storytelling and iconography prompted consideration of whether these tools can be employed to enhance accessibility of abstract concepts in robotics teaching. Storytelling is frequently used to recount historical and cultural events and actions. Through extension of this process, storytelling can be used to describe the actions of robotic devices such as the LEGO® NXT. The authors postulated that using a storytelling mechanism as an introductory method of teaching programming would be effective as it draws upon a concept students are familiar with, and consequently scaffolds the programming process.

Aim

The aim of the project was to trial the integration of iconography and storytelling in the initial phase of a robotics program to enhance development of programming skills in icon-based programming languages like LEGO® Mindstorms® in P-7 schools in rural and remote areas of northern Queensland. The purpose was to enhance student engagement in the learning program and improve outcomes. It was proposed that the use of storytelling would allow students to develop solutions to programming problems in a way that is meaningful for them, rather than using direct and sometimes confusing constructs like sequence, selection and iteration. This, coupled with iconography, was anticipated to provide students with mechanisms for understanding and applying the required metalanguage that is associated with traditional programming.
Method

A one-day Storytelling and Iconography Robotics Program (SIRP) was developed to be delivered to students in rural or remote areas with little or no previous experience of robotics and programming. The SIRP was designed for delivery by two teachers with extensive robotics teaching experience and with the students’ regular teacher participating in the session. Sustainability of the students’ engagement beyond the SIRP education day was facilitated by the provision of robotics equipment, software, learning resources and digitally delivered support for the site teacher.

The SIRP was developed through a partnership between the Department of Education Queensland, Cairns State High School, LEGO International and the Royal Flying Doctor Service (RFDS) of Australia. The school provided two teachers to project manage the trial and to develop and deliver the SIRP; LEGO Education provided the robotic resources and support for the teachers and the RFDS provided community connections, transport to remote sites, and cross-cultural support.

The SIRP program utilised eight pre-constructed NXT LEGO® robots (approximately 300mm in length 150mm in width and 200mm in height), seven for student use and one for demonstration purposes. A standardised build was used for all robots and included several core components. These included two motors for movement, one ultrasonic for distance determination and a light sensor for light intensity determination. Seven computers with LEGO® Mindstorms® were used for programming.

The primary learning objective of SIRP was to develop student’s ability to identify a problem and logically sequence a solution within a programming environment by having the robots achieve a pre-determined goal. Secondarily, mathematic concepts like measurement, shapes and angles were intended to be applied and reinforced in the SIRP. Additionally, health related objectives were included in the two programs delivered in remote sites. Immunisations, hygiene and infection control awareness and care of people with broken bones were targeted in the learning. These concepts were integrated into the program to support the health education and promotion objectives of the RFDS and are important concepts for children in isolated areas.

The program was structured allowed students to initially solve simple problems such as driving the robot in a straight line before progressing onto harder problems. At each stage students would develop stories using icons to represent their solutions to the problems before converting this to the LEGO® Mindstorms® language. In this way students were able to have a clearer understanding of their solution in terms they easily understood before using less familiar programming icons. This process also allowed the introduction of the abstract concepts of sequence, selection and iteration in an informal manner.

The teaching strategy used three phases of learning; orientation, enhancing and synthesising. In the orientation phase students used a variety of storytelling approaches starting with an oral narrative. This storytelling framework supported teaching of a range of programming structures including sequence, selection and iteration. Students were asked to describe the process for completing a variety of simple activities including making breakfast, brushing teeth and crossing a road. The purpose was to personalise the activity such that all students can discuss selected activities to the necessary level of detail. This step-wise refinement process allowed the students to view the structure of simple events as a sequence, selection or iteration. For example, choosing a cereal for breakfast is a selection process, and the selection can be effected by a variety of factors including nutrition requirements, parental influences and items available. These influencing factors are referred to as the “Why?” component. In most programming languages this is analogous to the “criteria for selection” or in some instances “properties”. Students’ then built on their oral stories about everyday activities by presenting their stories using a collection of images (icons). At this stage students were encouraged to share their picture-based stories with other members of the cohort to compare and contrast similarities and differences.
During the enhancing process students are introduced to a variety of familiar and unfamiliar standardised icons. The icons used include concrete examples like speed indicators, inferential icons like hazard signs and arbitrary icons like company logos. This process supports students to understand that icons are context dependant and can be flexibly interpreted. Using this core concept students wrote simple pictorial stories representing the movement of a NXT LEGO® robot from one location to another or the negotiation of a simple hazard like crossing water via a bridge. Using these icon-based stories students were introduced to the LEGO® Mindstorms® programming environment. Through a comparison process the students attempt to identify icons that are linked from their icon-based stories to the Mindstorms® programming environment. This scaffolded approach to programming provided opportunity for students to negotiate the gap between concrete icons like motors and inferential icons such as a pictorial representation of an ultrasonic sensor.

To further extend the learning process participants were provided with experimental opportunities, opportunities that allow collaborative group engagement to solve detailed and challenging problems using the robotic technology. This synthesising provides an opening for students’ access scientific and mathematical understanding in a unique and concrete way.

Site selection for delivery of SIRP was considered an important aspect in the trial and was managed by the coordinating teachers and RFDS (for remote sites). Selection was based on a number of criteria including rural or remote location in northern Queensland, demonstrated willingness to provide a coordinating teacher to assist in the management of the learning program, minimal or no previous exposure to an icon-based programming environment and a commitment to continued implementation of the learning program.

To evaluate the SIRP trial all participants including support staff were requested to complete a survey. Two surveys were developed by the authors; one for students and one for staff. The student written survey was designed to be completed immediately after the conclusion of the session and used open-ended questions to elicit participants’ views on the SIRP. The teachers’ surveys were designed to be completed verbally with notes taken by one of the supervising teachers of the teachers’ responses. Analysis of the survey data was undertaken by the coordinating teachers and comprised identification of common themes in the responses.

Results

Four SIRP sessions were delivered between February 2011 and November 2011. Sessions were delivered at two rural schools and two remote schools. Each session was approximately four to five hours in duration and included 14 to 20 students from prep to year 7. Each participating school provided one or more supervising teachers with additional support staff where required.

Forty-nine student surveys were completed. The student survey data indicated that the majority of students enjoyed the robotics session and believed the level of complexity used was perceived as appropriate for the learner. All survey respondents indicated that they would like to have access to further robotics sessions. The main supporting reason for this provided in the survey was that the session was fun and using stories and drawing pictures made learning interesting.

Five teacher surveys were undertaken. Overall the participating teachers believed that the students were successfully engaging in educational material in a fun and supportive environment. Specifically, both supervising teachers from one remote site saw opportunities for using robotics in mathematics in the areas of measurement and ratios. The teachers also indicated the use of iconography and storytelling as an introduction to robotics would potentially assist in the areas of literacy and procedural based areas like science. One teacher reflected that initial concerns regarding the appropriateness of the SIRP for a prep-age student in the school were allayed as the use of the storytelling and iconography provided adequate scaffolding to allow engagement in the learning.
Several concerns were raised by teachers in the surveys. Teachers expressed concern about their ability to apply robotics in the classroom and also their access to teaching resources. This concern was addressed to some degree by the provision of post-trial support from the authors and additional educational resources.

Discussion

Teachers experience difficulties supporting students to engage with programming concepts with vague connection to the learner’s experiences. This can limit opportunity for learner understanding and engagement (Abrahamson, 1998). Consequently it is necessary to implement a strategy that uses tangible experiences so that personal and emotional connections are possible. Through this approach it has been identified that the potential for learning abstract concepts can be more enduring (Egan, 1995). To ensure that the participating teachers from the selected sites gain the experience necessary to continue the robotics program the trial program was implemented with the supervising teachers being part of the learning process. The teachers were included in the setup and teaching process, providing them with the appropriate skills to continue working with the students using robotics. The authors observed an increase in teacher confidence when using and discussing robotics in the classroom.

The learning sequence developed in the SIRP utilises a variety of storytelling approaches starting with an oral narrative. The use of simple stories provides opportunity for participants to contextualise the learning process and provides a mechanism to maximise participation. The stories used at each site differed depending on student age range and location. This consideration was necessary as the cohorts have vastly different life experiences. Using the narrative storytelling framework it was possible to alter the complexity of the story to teach a range of programming structures including sequence, selection and iteration which are foundation concepts within most programming courses. Further expansion of these initial stories allowed exploration of a combination of structures (sequence and selection; sequence and iteration). This was achieved by focusing on a verbal refinement process similar to that of step-wise refinement used in many programming courses. This permitted both the storyteller and listener to relate in a meaningful way via personal experience (Abrahamson, 1998).

To facilitate the programming aspect of learning, the learning sequence built on the oral narrative and focuses on icon based storytelling. This focus was used to support participants to engage in the metalanguage specific to programming. Pictorial symbols are generally designed to be simple and concrete in nature so that their interpretation is easily defined (Paul et al., 2001). One of the main issues associated to icon based programming languages like LEGO® Mindstorms® is that at times they can be ambiguous in their interpretation which is reliant upon how the user interprets the icon. This knowledge is drawn for the authors’ personal experiences in teaching classroom robotics programming for the past six year. McDougall and Curry (2004) identify that one of the integral issues to icon effectiveness and usability is the context in which the icon is being interpreted. The authors have observed in their teaching experiences that younger students in particular can have difficulty accurately interpreting LEGO® Mindstorms® icons as some are abstract. Therefore it is necessary to consider students’ understanding of icons as a continuum beginning with concrete interpretation through interferential and concluding with arbitrary interpretation. To ensure student movement through the icon interpretation continuum it is necessary to build opportunities for the learner to develop mechanisms for bridging of the gap. This gap can be referred to as semantic distance and can best be understood as the closeness between an icon’s representation and its intended meaning (McDougall et al, 2004).

Semantic distance plays a substantial role in the correct application of the icons (Isherwood, 2007). Paul et al (2001) further identified that cultural backgrounds and experience influences icon identification. The SIRP drew upon this issue of semantic distance to ensure that scaffolding
occurred prior to the use of the programming software LEGO® Mindstorms®. This was achieved by utilising student-created iconography for telling stories of daily experiences and then connecting this imagery to the icon based programming language. The application of this staged process provided the participant with the opportunity to make meaning through pattern association which reduces the semantic distances of the complexities associated to icon based programming language. In the SIRP program the authors viewed a notable improvement in the student’s application of inferential and abstract icons once completing the appropriate scaffolding.

Conclusion

The SIRP program is only in the initial phase of the program development. It is evident that there is a potential opportunity to use this foundation approach to improve outcomes for students in the introductory phase of programming. The influences of implementing storytelling scenarios which are connected to the learner and application of iconography as a method of teaching structures are yet to be fully realised. Consequently additional field trials are needed and more rigorous evaluation techniques need to be applied. However several elements have been highlighted in this initial trial of the program; learning is more successful when it is personal to the learner and when developing learning programs the learner’s background has a significant influence on the way the individual approaches the learning process, and using robotics in the classroom can provide an opportunity for students to engage in science, technology, engineering and mathematics in a concrete and engaging way.

Acknowledgements

- Dr Collin Baskin, Cairns State High School
- Sandra Googan, LEGO Education
- Frank Aragu, Royal Fly Doctor Service (Cairns Base)
- Judith Taylor, Royal Fly Doctor Service (Cairns Base)

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