ROBOTS IN PROBLEM-SOLVING AND PROGRAMMING.

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ABSTRACT

This paper looks at the experience of teaching on a module where problem-solving is taught first, then programming. The main tools for the problem-solving part, alongside two problem-solving approaches, are tasks based on using Mindstorm (LEGO, Denmark) robot kits. This is being done as a foundation step before the syntax of a language (Java) is taught. Results of student evaluation will be presented.

Keywords

Student experience, problem-solving, robots, Java.

INTRODUCTION

Mindstorm based robots have been used previously for teaching programming to computing and engineering students [1, 2]. As part of the teaching of problem-solving in a first year programming module, the role of using robotics is under investigation. Preliminary work within the team [3] suggests that using LEGO robots within the teaching of problem solving has some benefits for the students.

The module was divided into eight weeks focusing on problem-solving techniques and sixteen weeks of programming in Java. Two assessments are linked by a robot-based task in the problem-solving assignment, which is developed further into a graphical emulator in the programming part of the module.

PROBLEM-SOLVING

Problem solving is not trivial [4]. Two explicit but related problem-solving approaches are taught. The first is based around analysis, design, testing design, implement and test. The second approach is basic the same as the first, but includes brainstorming and is therefore more suited to group working [5]. A series of small problem-solving tasks were provided to give the students practice in trying out these problem-solving approaches and to learn from their mistakes. Some of the problems included ambiguities or were ill-defined, to enable the student to resolve as part of the process. An example of this is “Calculate the area of a rectangular room”. What does this mean? Floor area or does it mean area of floor, ceiling, and four walls?

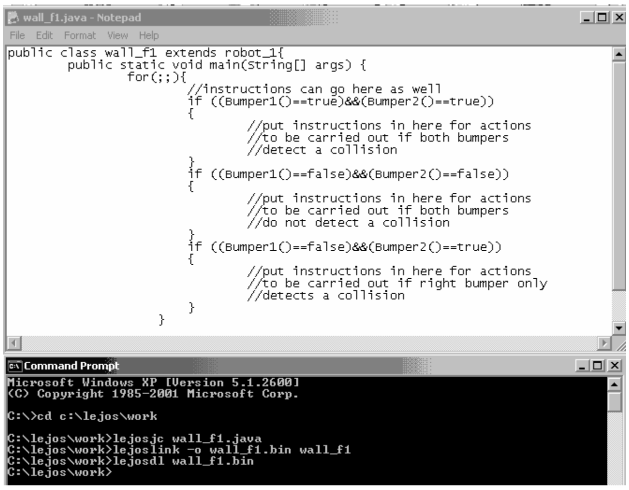

Figure 1. Template for the wall-following routine and downloading the routine to the robot.

Mindstorm robots formed the core of the problem-solving activity, based around six exercises, with gradually increasing difficulty, one of which formed part of the assessment. The assessment included a task which involved the student producing a list of instructions to get the robot to trace a letter ‘M’. The assessment task was also developed further in the programming assignment where they were asked to repeat the same exercise but as a graphical simulation. The student’s were given a simple set of instructions to control the robot and templates for each exercise to fit these instructions into (figure1).

Two questionnaires were used as part of the evaluation of the approach. One at the beginning of the module to investigate student's initial thoughts and concerns with problem-solving. A second one after the robot exercises was used to gauge the response to inclusion of robots for teaching problem-solving.

The first question asked was did they think that robotics based problems help with developing problem-solving skills; all respondents said it did. When asked how it helped, the main two types of comment (50%) suggested the approach provided a physical or visual representation of the problem or enabled the problem to be viewed in different ways (figure 2).

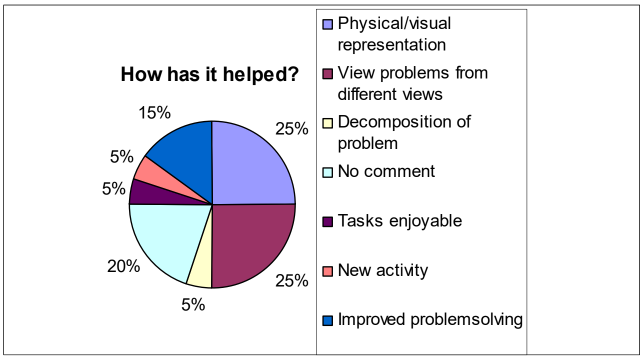

Figure 2. Student's view on how the robot-based approach helped.

Approximately 81% of the respondents said they did enjoy this approach and 19% said it was okay. When asked about the positive aspects of the approach (figure 3) 13% of the respondents did not provide any further comment. The physical representation of the problem and visualization accounted for 68% of the comments.

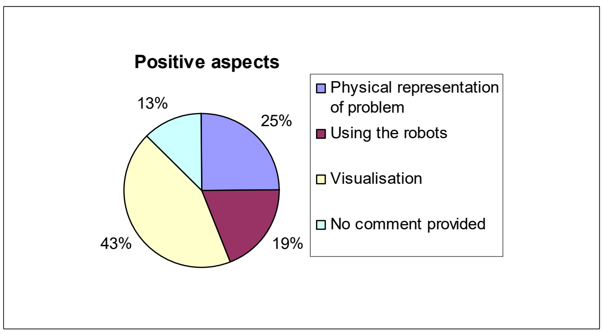

Figure 3. Student's view on the positive aspects of robot-based approach.

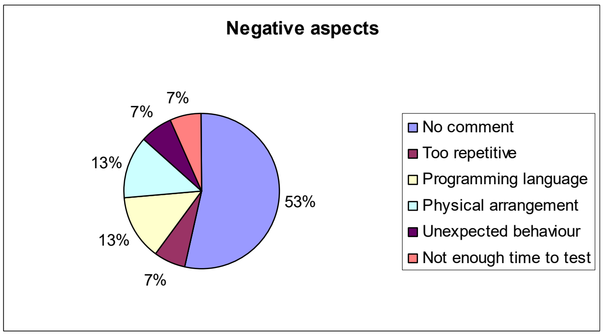

Figure 4 Student's view on the areas for improvement of robot-based approach.

Figure 4, represents some of the areas for improvement, though 53% respondents have no further comments. 13% of the comments said the physical arrangement of the robots (usually not enough sensor or not interesting exercises) needs improvement. A further interesting point is 13% of the comments said the problem was with the programming language.

PROGRAMMING

Java programming forms the second section of the module (16 sessions of 1.5 hours duration). The approach taken is to get the students producing Graphical User Interfaces (GUIs) at the earliest possible opportunity. A recommended course text [6] was used to facilitate the GUI programming.

This section of the module was assessed by the production and documentation of a java GUI application that emulated the movement of a robot in an approximate letter 'M' shape (lower or uppercase the choice was up to the student). It was expected that the design would be based upon an adaptation of the previous robot routines produced in the earlier assignment. A test method `runRobot()` was provided, this method was to be used to draw the 'M' in figure 5.

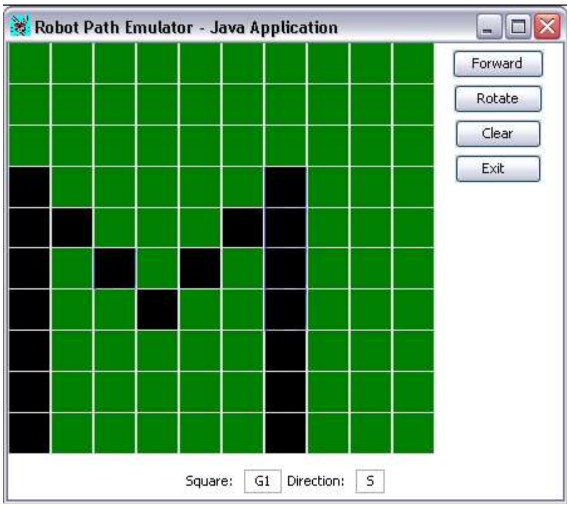

Figure 5. Prototype GUI application from the programming exercise.

As in the problem-solving section the grades, feedback and engagement with the activity were positive. The idea of linking the problem-solving and programming assignments with the same task, was seen as a positive feature. One student made the explicit comment that they felt there was a 'good progression from problem-solving to programming'. In addition, the students commented that they could take the ideas developed in one part of the module to the second part, thus evidencing clear transferability of skills.

The module tutor has found that the students not only find the programming of GUIs in Java challenging and interesting, but fun and exciting. The 'eureka' moment is evident with each small problem solved and the increasing functionality of their GUI application. It is felt that visual programming itself aids their engagement, enjoyment and learning. On occasion they have had to be discouraged from spending too much time on this assignment at the detriment to others.

Discussion

One of the features suggested by figure 4 is that the student's still see this is a programming exercise.

To compare the results from the problem-solving tasks and the related task in the assignment, the two sets of grades (with their mean values removed) was plotted (figure 6).

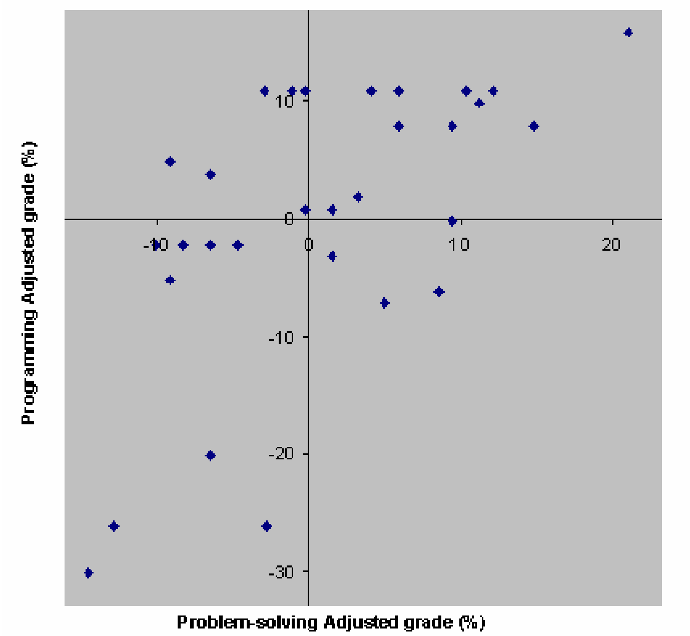

Figure 6. Relationship between results from the robot-based problem task and the programming assignment.

There was a correlation coefficient of 0.61 between the results of the problem-solving exercise and programming exercise. Figure 6 suggests there is some correlation between success with the robot-based problem and programming success. Student satisfaction for both parts of the module is over 92%. One of the comments that was made was they liked the linking of the problem-solving robot task and the programming assignment.

Conclusions

This is an area which the authors feel can be developed further. The results suggest this approach is worth investigating based on the indicative increase in grades and the positive response of students. The improvements to the approach that were suggested by the student can be summarised as more access to the robots, possibly more featured robots, and increased difficulty of the exercises.

The main benefit was that the students believe robots provide a method to visually and physically see the outcome of a problem. The approach taken in both parts of the module has been visually-orientated. The appropriateness of this seems to be borne out by the student comments.

A limiting factor to the approach is availability and numbers of the robots. It is not possible for the robot kits to be available 24 hours a day or to be taken home by the students. An area under investigation is to develop the material, instead of based around these robots, using Microsoft's Robotics Studio. Microsoft Robotics Studio is free so is readily available, and is part of Microsoft's growing interest in robotics [7]. This has been selected to still keep some of the advantages of the robot-based approach, but increase flexibility of where and when the student's can use the material. This increases the flexibility of where the student can work on this material and fits in this the university E-learning strategy.

Currently the approach is best described a problem-solving learning [8]. A possible further direction that is being considered for the problem-solving part is a problem based learning approach [4] which seems a sensible direction to take this work. This will be done by making the problem a little more open, and the tutor's role become much more about assisting them in groups with their problem. This would also help address the possible concern over the ownership of the problem, moving the problem from one that the tutor sets to their own problem.

ACKNOWLEDGMENTS

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