

Teaching Robotics Through Play and Challenge

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Subject area: Electronic and Electrical Engineering / Robotics.

This case study has been developed from data gathered through a demonstration of the teaching and learning materials available, interviews with the tutor and a student focus group.

Background

The Robotics 4 course is taught in the final year of a Scottish university Electrical and Electronic Engineering degree programme. There are approximately 20 students per year who are studying for a variety of degree awards at B Eng. (honours) or M Eng. level. Most of the students are from the UK with good A-levels or Highers, though there are several overseas students on EU exchange programmes. The first part of the robotics course covers sensors and actuators and is taught by conventional lectures; this report concerns the second part of the course, taught by a different member of staff, that covers the theoretical and mathematically intensive kinematics, dynamics and control aspects of industrial robotic manipulators. The aim of the approach taken is to balance the presentation of challenging mathematically-intense theoretical material with a play aspect designed to allow practical experimentation that reinforces topics learned earlier in the course.

Active participation of students during the lectures is ensured through direct questioning of students (for example at the beginning of a lecture to reinforce pre-requisite concepts), having students "act-out" the movements of a robot arm, and students working through example problems in front of the rest of the class. Students participate individually, though each student knows that they may be the next to be chosen to take part. To balance these potentially stressful activities there is a break at the midpoint of each lecture.

In parallel to these lectures students also work as teams to build and programme an autonomous robot of their own to take part in a challenge at the end of the course (either Robot Olympics or robot versus robot combat). The robots are built using LEGO™ Mindstorms™ kit, which was donated by LEGO, and programmed in C. The challenge requires that they put into practice the material about sensors and actuators taught in the first part of the course, for example they must use a light sensor to avoid certain regions of the arena, and must be able to actuate weapons when they are within striking range of another robot.

Reasons

The lecturer describes the two aspects of the approach as carrot and stick. LEGO Mindstorms is intended to introduce an element of play to the course, allowing the student to have fun and use their imagination. The hope is that this will stimulate the student's interest in robotics in general and thus stimulate their interest in the rest of the course. It is also the aim to create a relaxed and friendly atmosphere for the course as a whole and so encourage the students to participate in the lectures. The LEGO Mindstorms system was chosen for this part of the course since it was different from the rest of the course, and so wouldn't be associated with aspects the students might find difficult, but also includes programmable actuators and sensors and so ties in with the subject matter of the first part of the course.

The approach to lectures is deliberately designed to challenge the students. As a class, they are continually questioned about the subject matter and individually they take turns to come to the front and work through example problems. The questioning drives them to learn the taught subject matter so that they feel adequately equipped to answer questions in the lectures and reinforce their

knowledge base. Also, participation by jointly undertaking examples during the lecture period, enables the students to engage with the learning objectives of the lecture through practical examples. In addition, the physical act of writing on the board allows students to breach the barrier at the front of the lecture theatre and take responsibility for the pedagogical outcomes of the lecture.

The balance between play and challenge is important so that the students don't treat the subject as trivial or find it too stressful.

Lecturer's Perspective

The lecturer found developing activities in LEGO to be fairly straightforward: there is an overlap with his research interests and "it doesn't take an awful lot to become reasonably expert". There are some limitations in the default Mindstorms kit that required modifications to be made, for example C is used as a programming language rather than Logo, however the lecturer feels that it is useful for the to be some limitations that the student has to design around.

Care has to be taken that no student feels too pressured by the challenges presented in the lectures. The challenges mustn't be too great, and students must receive some motivation and encouragement even if they get an answer wrong. The aim is to create a relaxed working atmosphere where students are "treated as individuals rather than a collective cohort", however it is also important to make sure that the students stay focussed on task. The age of the students helps: they are in their fourth or fifth year of university study and so less easily distracted than first or second years. In general each student only deals with a fairly small part of an example problem, if they get stuck the problem is thrown back at the class, and all students know that they could be next, which acts as an incentive for paying attention.

Students' Perspective

Two key issues about the students' perspective on this approach to teaching are whether they find the LEGO labs to be fun and motivating and whether the level of challenge in the lectures is appropriate to encourage engagement but not to be too stressful.

Through questionnaire returns and observation it was clear that the students enjoyed aspects of the LEGO labs: from 18 questionnaire returns 13 strongly disagreed with both the statements that the LEGO lab sessions were "boring" and were "unnecessary"; the atmosphere for the final robot combat challenge was clearly one where the students were enjoying themselves. All students bar 3 agreed that the LEGO labs increased their motivation to learn. When asked by questionnaire about the aspects of the course they liked, most students volunteered the opinion that it was fun, more interesting, or at least less boring than lectures. Through the questionnaire and interview the students gave various reasons for liking the LEGO labs, including the opportunity for teamwork, building a functioning robot from scratch, and seeing how theoretical aspects of the course worked in practice (or in some cases don't work).

In questionnaire returns two students agreed with the statement that the approach to lecturing made them feel uncomfortable (e.g. nervous or picked-on) as a result of the approach taken to teaching, most (10) of the other students strongly disagreed with this statement. Interestingly, the two who agreed with this statements that the approach increased their motivation to learn and helped them keep up or increased their depth of understanding. As one student said in the interview, "when you are at the blackboard you are a little bit nervous but you are much more active so you learn better".

Some students in the interview suggested that the LEGO exercise was too far removed from the rest of the curriculum, and that less material was covered in this course than they would have liked. This was a minority opinion within the group, others had the opinion that exercises more closely related to the topics being taught probably wouldn't add much to the lectures, and all agreed that there was a balance to be struck between depth of understanding and breadth of material covered.

Issues

Care needs to be taken to get the balance between play and challenge right and a conscious decision has to be made to cover less material in greater depth when taking this approach.

Benefits

The majority of students are strategic learners—appealing to this throughout course improves chance that this will go deeper rather than just be surface learning for the exam. One student said "you can learn all the stuff for the exam but it goes straight out of your head [...] interacting with stuff this way—it's going to stick" "you actually learn". Students are motivated by the practical and play aspects, one "wanted turned up to all the labs because of the LEGO", another said that building a robot "is a good thing to get out of a course called 'Robotics'"

Reflections

The approach to lecture successfully engages the students' attention, and the play aspect successfully increases students' motivation for the course as a whole; the balance between the two has created an approach to teaching a mathematically intense course that students find rewarding. Students in this class described being in a "class room with teacher rather than lecture hall with lecturer", they described their teacher as someone who "talks to you rather than over you" and "treats you like an individual".

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