Laughter over Dread: Early Collaborative Problem Solving through an Extended Induction using Robots

Mark Zarb
School of Computing Science and Digital Media
Robert Gordon University
Aberdeen, United Kingdom
m.zarb@rgu.ac.uk

Michael Scott
Games Academy
Falmouth University
Cornwall, United Kingdom
michael.scott@falmouth.ac.uk

ABSTRACT
Software development companies want new hires with strong interpersonal and problem solving skills. To ensure the development of such skills, they must be embedded throughout the curriculum. However, many students struggle to collaborate with peers and in self-regulated practice during the early stages of their course. Explicit scaffolding can, however, motivate such engagement. This tips and techniques session shows how an ice-breaker using LEGO EV3 robots at two UK institutions enhanced peer interaction and increased self-regulated practice over the first four weeks of 2016-17 and 2017-18.

CCS CONCEPTS
• Social and professional topics → CS1; Computational thinking; Model curricula.

KEYWORDS
Interpersonal Skills, Teamwork, Problem Solving, Induction, Communities of Practice, Robots

1 INTRODUCTION
The development of human capital in order to drive economic well-being has become a prominent focus of higher education. In recent years this has led to employability skills becoming central to definitions of student success. Employers in the technology sector often raise concerns about graduate employability, highlighting needs for interpersonal and problem solving skills [5]. The Shadbolt Review [9] echoes these concerns, illustrating that computing graduates require significant dedication and a sound strategy to develop [2]. Therefore, encouraging students to practice their interpersonal and problem solving skills early in the curriculum, such as the CS1 context, would afford greater time for students to develop them. Especially if it encourages subsequent self-regulated learning that is constructively aligned with employers’ expectations.

However, challenges do arise. Firstly, establishing a context which inspires self-regulated practice. First-year students struggle to sustain their engagement without ongoing encouragement [4]. There is, therefore, a need to frame problem solving activities using approaches that encourage self-regulation (e.g. [15]). Secondly, when navigating the transition into higher education, many struggle to form a community of practice and engage with their peers [10, 12, 14]. Thus, they tend not to practice their interpersonal skills in a problem-centric manner early enough in their course.

Falmouth University and Robert Gordon University, together, have been exploring solutions to these challenges. While conducting previous research [7, 8, 13], the authors observed that students seemed to engage in peer support more readily, and were less intimidated by logic errors, when programming robots. Such activity seemed to evoke a sense of mastery, belonging, and agency, in line with building motivation according to self-determination theory [1]. To this end, the authors put together a series of induction activities centered upon notions of collaboratively building and programming robots.

2 INDUCTION DESIGN
Each team needs to have enough components to be able to build a basic Mindstorms robot (Figure 1), although this activity could be tweaked depending on available materials.

The LEGO Space Challenge using Mindstorms EV3 robots forms the thrust of the induction, organized into four key stages:

Introduction. A general introduction is given to the class, where students are divided into teams. Each team is handed a box containing all the components required to build a basic Mindstorms robot, a step-by-step handbook for construction, and an introduction to the coding interface.

Challenges. Once all teams have built the basic robot (or after a set time period), a document containing all the challenge briefs are handed to the teams. This can be supplemented with videos showcasing each challenge, to give teams a general consideration of the solution.
Development Time. Teams then being to solve the given challenges. The challenges themselves are set out so that teams can test their robot, so they can devise solutions using an iterative approach.

Competitive Play. At the end of the timescale, teams are asked to participate in the challenge event, where they are required to solve all challenges within a set time period. Each team’s time taken can be used to populate a leader-board and announce the winning team.

The instruction given to students is fairly minimal: students are placed into teams, asked to build a basic robot from a number of parts as a common starting point, and then given a set time period to build and program the robot to solve a number of predetermined challenges. This forces them to work in multidisciplinary teams from the start, and learn to approach problem solving in an explicitly collaborative context.

3 FINDINGS
Variations of these sessions have been run annually since 2015 at Robert Gordon University, and since 2016 at Falmouth University. Extending already known benefits of educational robots in the programming context [6], qualitative data from observations and an end-of-task survey at both sites support hypotheses of improved collaboration and problem solving. Notably, students reported that it was fun to solve problems with the robots and that this activity was a great ice-breaker to make them interact with each other to build these robots and discuss out-of-the-box solutions. Further to this, many students successfully completed the space challenge, demonstrating key computational thinking skills.

This approach allows students to start working with each other without the expectation and pressure of grades, reaping the benefits of an informal experience. It was observed that students were successful in learning the foundations of computational thinking using LEGO robots, and that feedback from these challenges often resulted in “laughter rather than dread”, encouraging the students to continue problem solving. This was deemed an excellent ice-breaker that opened up dialogue between newly-met peers. Furthermore, staff reported that these sessions allowed students to form small communities of practice early in the academic year, and that students tended to refer to these communities for support throughout the semester, even after the induction had ended.

REFERENCES
[1] Edward L Deci and Richard M Ryan. 2008. Self-determination theory: A macrotheory of human motivation, development, and health. Canadian psychology/ Psychologie canadienne 49, 3 (2008), 182.
[2] K Anders Ericsson, Ralf T Krampe, and Clemens Tesch-Römer. 1993. The role of deliberate practice in the acquisition of expert performance. Psychological review 100, 3 (1993), 363.
[3] Innovation Great Britain. Department for Business and Skills (BIS). 2016. Computer science graduate employability: qualitative interviews with graduates. (2016).
[4] Tony Jenkins. 2001. Teaching programming:– A journey from teacher to motivator. In The 2nd Annual Conference of the LSTM Center for Information and Computer Science.
[5] Ian Livingstone and Alex Hope. 2011. Next Gen: Transforming the UK into the world’s leading talent hub for the video games and visual effects industries. National Endowment for Science, Technology and the Arts (NESTA), London, UK (2011).
[6] Louis Major, Theocharis Kyriacou, and O Pearl Brereton. 2012. Systematic literature review: Teaching novices programming using robots. IET software 6, 6 (2012), 502–513.
[7] Michael James Scott, Steve Counsell, Stanislaus Lauria, Stephen Swift, Allan Tucker, Martin Shepperd, and Gheorghita Ghinea. 2015. Enhancing practice and achievement in introductory programming with a robot olympics. IEEE Transactions on Education 58, 4 (2015), 249–254.
[8] Michael James Scott, Alcwyn Parker, Brian McDonald, Gareth Lewis, and Edward J Powley. 2019. Nurturing Collaboration in an Undergraduate Computing Course with Robot-themed Team Training and Team Building. In Proceedings of the 3rd Conference on Computing Education Practice. ACM, 5.
[9] Nigel Shadbolt. 2016. Shadbolt review of computer sciences degree accreditation and graduate employability: April 2016. (2016).
[10] Angela A Siegel and Mark Zarb. 2016. Student Concerns Regarding Transition into Higher Education CS. In Proceedings of the 2016 ACM Conference on Innovation and Technology in Computer Science Education. ACM, 23–28.
[11] UK Tech City. 2016. Tech Nation 2016: Transforming UK industries (pp. 1-65, Rep.). Tech City UK (2016).
[12] Mark Zarb, Bedour Alshaigh, Dennis Bouvier, Richard Glassay, Janet Hughes, and Charles Riedesel. 2018. An international investigation into student concerns regarding transition into higher education computing. In Proceedings Companion of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education. ACM, 107–129.
[13] Mark Zarb, Janet Hughes, and John Richards. 2015. Further Evaluations of Industry-Inspired Pair Programming Communication Guidelines with Undergraduate Students. In Proceedings of the 46th ACM Technical Symposium on Computer Science Education. ACM, 314–319.
[14] Mark Zarb and Angela A Siegel. 2017. An Analysis of Pupil Concerns Regarding Transition into Higher Education. In Researcher Links Workshop: Higher Education for All. Springer, 3–16.
[15] Barry J Zimmerman. 1998. Academic studying and the development of personal skill: A self-regulatory perspective. Educational psychologist 33, 2-3 (1998), 73–86.