Promoting STEM via Robotics based Programming

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Abstract

There has been much criticism of the lack of programming in secondary level ICT teaching provision in Northern Ireland. There are more than 900 companies in the ICT sector and many of these are international organisations. It is against this backdrop that we need to promote secondary level programming education and to do so, we ran three separate 3-day interactive workshops (outside of classroom time) in three different schools covering different demographics, under a funded project entitled Widening Access Robotics Programming (WARP). The aim was to give the students a feel for what they would be doing when studying both Software Systems Development and other STEM subjects in Higher Education (HE), in a fun and novel way. This was achieved by learning industry standard programming languages (e.g., Java) and using them to program a Lego Mindstorms EV3 robot. This visual demonstration inspired students to learn programming and helped students understand programming in a practical manner. The feedback from the students showed that 88% of students were positive about their learning throughout the course and no students were unhappy with the course.
Keywords— Interactive learning, Programming, Robotics, Widening Access

1. Introduction

Programming or coding is the process of developing sets of instructions (computer programmes) that enable computers to carry out tasks. There has been a continuous increase in the number of students taking the United Kingdom's GCE A-Level Information, Communication and Technologies (ICT), with approximately 1450 students taking this course in 2013 [1]. The A-Level ICT course does not include any programming elements. Conversely, the newly introduced A-Level Software Systems Development course, which includes programming, attracted only 37 candidates in 2013, growing to 173 in 2014 [2]. The difference of uptake in these courses is stark. The growth of the IT industry has been identified as a top priority for the Northern Ireland Executive. According to InvestNI, Northern Ireland is the leading foreign direct investment region in Europe for software development and IT technical support centres [3].
To educate young people to the required standards to fulfil the demand for IT jobs and continue the growth of the sector, young people need to stay in post 16 education. There are several ways that we can inspire young people to stay in education. Firstly, by making them aware that an average young person who stays in education earns £100,000 more over their lifetime than those who don't [4]. Furthermore, it is critical that suitable education routes are provided for young people so that they can select a route that suits their needs and skill sets. It is also proven to be beneficial for young people to have employers and industrial partners involved in the design of the curriculum content to ensure they become equipped with skills to meet the expectations of employers. We should also provide with the correct training for their career in school and the information that enables them to make informed decisions. It is with this premise that the Widening Access Robotics Programming (WARP) course was developed. The WARP program introduced programming into secondary schools in a fun and novel way by learning university and industry standard programming languages (e.g., Java) and using them to program the Lego Mindstorms EV3 Robot (Figure 1).

Figure 1 – Image of Lego Mindstorms EV3

It was felt that a visual demonstration would inspire students to learn and understand programming in a practical manner. The courses were held in schools which aligned to widening access policies and focussed on schools and cohorts which are historically underrepresented in STEM careers, for example female schools [5].

2. Project Overview

The WARP program consisted of 3-day interactive workshops in three different secondary schools covering different demographics. We facilitated courses in a female school and a Protestant and multi-cultural school to address under represented cohorts within STEM related degree programmes. This project was inspired by a previous 'Introduction to Programming' course, namely "Widening Access Through Introducing Programming in Schools" (WABIPS), which was delivered in a number of local secondary level schools over a period of three years. The WABIPS course provided Year 13 and 14 pupils (16-18 year olds) with sufficient knowledge to help them make informed decisions on undertaking further study and a career in computing and engineering disciplines, thereby improving retention within the subject [6].

One of the core aims of the WARP course was to address the issue of non-completion or failure of first year students on STEM related degree programmes by targeting schools that currently have pupils who progress to courses within the School of Computing, Engineering and Intelligent Systems (SCEIS) in Ulster University (UU). Non-progression to Year 2 is a significant problem within SCEIS courses at UU with a non-completion rate of 8.6% (2017/18 entrants). Reducing the number of early leavers will, in turn, lower the rate of non-completion, currently 14.4% for SCEIS courses which is significantly higher than the UK benchmark of 9.7%. The high rate of non-completion within the SCEIS is mainly due to a high rate of early leavers (who often indicate that the course was not what they had expected). SCEIS continuously strive to decrease the number of students failing first year and the WARP project would help significantly in this respect. By introducing programming to secondary schools, we aim to give the students a feel for what is involved in studying STEM subjects in HE.

In the first course delivery of the WARP project, we specifically addressed the issue of gender in addition to retention. According to the Widening Access audit, in terms of full-time undergraduate students UU is a 'female' university with an average of 60% full-time entrants being female. However, as seen in Table 1, within SCEIS the percentages of female full-time entrants in academic years 2016/17 and 2017/18 were 23.4% and 18.5% respectively; significantly lower than the overall university percentage. Although the figures in Table 1 conform to traditional gender patterns in engineering and computer disciplines, gender imbalance is still an issue that needs to be addressed.

Table 1 – Gender breakdown of entrants to SCEIS

	2016/17 (#students)	2016/17 (%)	2017/18 (#students)	2017/18 (%)
Female FT	49	23.4 %	32	18.5 %
Female PT	1	25.0 %	0	0.0 %
Male FT	160	76.6 %	141	81.5 %
Male PT	3	75.0 %	5	100.0 %

In the third 3-day WARP course, we addressed the issue of religious imbalance, in terms of the Catholic – Protestant divide. At UU, over 60% of full-time undergraduate students are Catholic. We addressed this by specifically including Protestants schools in the third 3-days WARP course.

With the inclusion of all cohorts of students, particularly minority groups such as females, we can improve the employability of young people in Northern Ireland and the UK. The Northern Ireland (NI) June 2017 Skills Barometer 'Skills in Demand' Report [7], forecasts an under-supply of Engineering and Technology, Maths and Computer Science graduates to 2026. One of the areas recieving huge investment is Artificial Intelligence (AI), a field of Computer Science whereby computing software can analyse data, learn from the information and make decisions with higher accuracy and speed than humans can [8]. Increased use of AI can bring major social and economic benefits to the UK and further afield. It has been estimated that AI could add an additional USD $814 billion (£630bn) to the UK economy by 2035 [9]. Through courses such a WARP, we can provide young people in Northern Ireland with an opportunity to get a flavour of the type of computer programming that they could use for completing a degree in a STEM related subject and subsequently gain employment in exciting fields such as AI.

3. Discussion

Throughout the three 3-day courses, continuous feedback was retrieved from the students by asking them to complete a novel feedback sheet each day. The sheet consists of a mix between a happy sheet and a minute sheet. The sheet presented the students with three emoji's symbolising sad, neutral and happy, and two open questions. Following analysis of the Likert scale, the quantitative feedback showed that 13% of students had neutral feelings and 87% were positive about their learning throughout the course. No student highlighted the sad face and every student emphasised that they enjoyed the course, particularly the interaction with the robots.

The open questions provided the students with the chance to oultine how much they had learned from the session and highlight any area that they wanted/needed more clarity on. For example, some students stated areas such as: "The functions of Java" or "the robot area". This continuous feedback was invaluable to the successful delivery of the course as it allowed the facilitators to dynamically change the focus of the learning each day. For example, we were able to reiterate what the functions of the Java programming language were and how to use them. Also, we played videos of the high-level robotics research from our Cognitive Robotics Research Group from the Intelligent Systems Research Centre (ISRC), providing the students with more information on robotics and to inspire them towards being successful programmers.

The qualitative feedback evidenced the practical aspect of coding the robot was inspiring and a strong learning aid. The majority of students from the three courses stated that they felt that they had successfully "Learned how to program using Java" and that they really enjoyed learning how to "create robot code".

On the last day of the courses the students programmed the robots to successfully navigate through a maze. The students raced the robots to see who could program the robots in the most effective manner. This generated a competitive learning atmosphere which supported strong peer assisted learning and was extremely enjoyable for the students and the lecturers delivering the courses. It brought an element of gamification to the course which is a proven method for successful learning. Although there are many benefits of using gamification in a classroom, it's best use is to help students review what they have already been taught as games will help them relate the topic to enjoyable learning experiences and make learning more fun, enjoyable and successful [10]. We asked each of

the students if they had enjoyed the course and if it inspired them to apply for a STEM related programme in higher education. The majority of students said they had no doubt that they would apply for a STEM based degree, in particular Computer Science. A number of students also stated that they would apply to attend a degree at UU, although they may not have previously considered UU. One student stated at the end of the course: “if it was my job every day to program robots, I wouldn’t even feel like it is work because I enjoy it so much”. This statement is one of the student testimonies which depicts the success of the course and the potential impact it could have on future applications to STEM related degree programs.

4. Conclusion and Future Work

The WARP project is an innovative initiative to take programming to local schools in Northern Ireland in a fun and interactive way by teaching students how to program a basic robot. The course aimed to encourage young people into higher education, consider computing or engineering as a potential career path, and improve understanding of what computer science at university level means. We have presented the initial feedback and findings from the three-day courses. The results indicate that students thoroughly enjoyed the course and felt they have successfully learned the basics of the Java programming language. It was evident that the inclusion of a basic robot inspired the students and added a fun, competitive and peer assisted learning aspect to the course. We aim to facilitate this course again in the coming years and analyse the effects on students entering first year who previously participated in the WARP program.

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