INSPIRING COMPUTER SCIENCE EDUCATION IN A WIDENING ACCESS CONTEXT WITH TECHNOLOGY

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This paper summarises a regional widening access STEM initiative in utilizing computing programming for RaspberryPI, Arduino, Lego Mindstorms and Quadcopter Drones in a Continuing Professional Development (CPD) course targeted at IT teachers from schools with a demographic that aligns with the University's widening access strategy. The paper reports on the results from a second run of a "Teach the Teachers" (T3) programme and tracking their views of Technology Enhanced Learning for Computer Science Education (TEL4CSE) before and after the CPD course.

The paper will firstly address the regional environment and associated statistics that highlight the various achievement gaps. It then goes on to describe the widening access project including the CPD T3 TEL4CSE course that targeted schools with a high percentage of pupils from the categories at the lower end of the spectrum of achievement. The paper then presents some of the results and feedback from the teachers on the CPD course and highlights how it is influencing their practice in school before concluding with future plans for the initiative.

The outreach initiative has been a success to date and the data indicates that the teachers have left enthused and believe it will help with improving and motivating the pupils in the lower achievement categories. The teachers will be contacted at 6 months, 12 months, 18 months and 24 months to monitor progress. From the feedback it is also intended to offer further CPD advanced courses in each of the technologies.

Keywords: Widening Access, Computing programming, RaspberryPi, Arduino, Lego Mindstorms and Quadcopter Drones, CPD (Continuing Professional Development)

1   INTRODUCTION

The impact of technology on our daily lives continues to increase profoundly. Technologies that claim to streamline our social behaviour, our workplace efficiency and our efforts to improve teaching and learning are at the forefront of today's society [9][15][20][21]. The availability of personal computers and the ease of access to the internet for young people, continue to influence the goals of education as well as its research [5]. The Northern Ireland Education System has been the subject of ongoing social and political research [8][10][13]. Within the Northern Ireland context this paper discusses a study that has been introduced to explore some of the emerging technologies that can be used in Computer Science education and the learning experiences of under-achieving social groups.

This paper firstly illustrates the Northern Ireland educational environment and associated statistics that draw attention to a number of achievement disparities. It then moves on to outline the widening access and participation project and the module developed to "teach the teachers" Technology Enhanced Learning for Computer Science Education which was the second "run" of the programme. The paper then presents some of the results and feedback obtained from the participants of the sessions and examines how the module has influenced their teaching practices. These results are comparable to the first "run" [16]. In conclusion future plans for similar 'Teach the Teacher'/ 'Train the Trainers' modules are discussed.

2 THE NORTHERN IRELAND EDUCATIONAL ENVIRONMENT

During 2014 the Department of Education for Northern Ireland published annual figures illustrating that there were in total 1,583 total schools and pre-school education centres in operation. Of this number 210 were post primary accommodating 143,973 pupils [2](DENI, 2014). The success of the Northern Ireland education system has been highlighted for continuously achieving top of the educational performance league tables in terms of GCSE (16 year olds) and A-Level (18 year olds) within the UK [1]**Error! Reference source not found.**[11]. However, it also has amongst the worst results for under achievement of school leavers within the United Kingdom. Regionally, Northern Ireland had retained the Grammar and Secondary Schools system with academic selection at 11 years old until recently when local Government removed selection, however the grammar sector are still using test systems operated independently by either or both of the Association for Quality Education and the Post Primary Transfer Consortium [22].

It is also important to highlight that Northern Ireland still operates for the most part a religious segregated education system. Figure 1 shows the proportion of school leavers who go onto Further or Higher Education varied by level of deprivation and religion. The areas in Northern Ireland are divided into quintiles (fifths) using the 2010 Northern Ireland Multiple Deprivation Measure. It indicates more pupils from catholic areas go on to participate in *Further* or *Higher Education* by as much as 14%
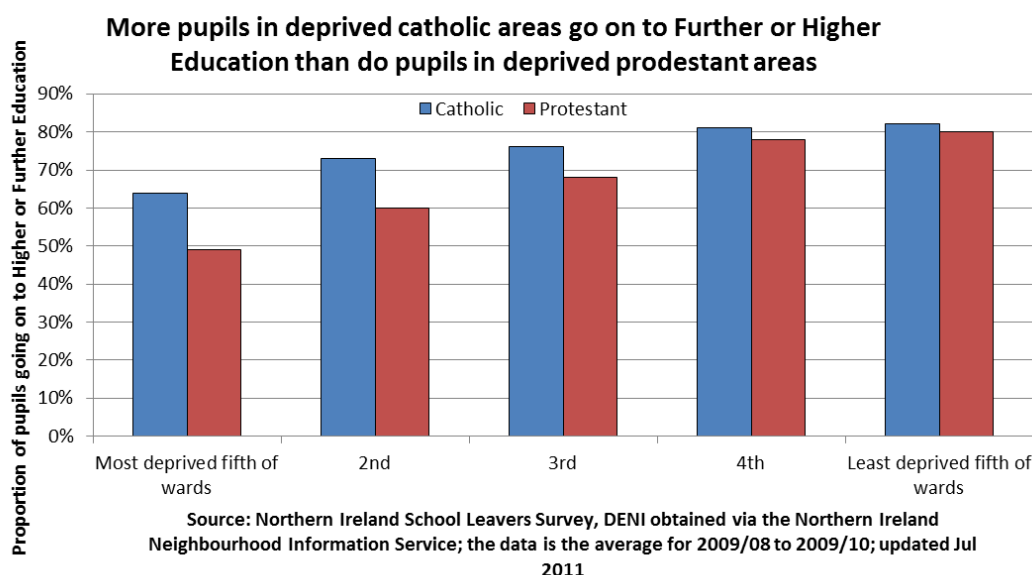

Figure 1. Proportions of pupils by level of deprivation and religion

From Figure 2 it can be clearly identified that the lowest performing social group within the Northern Ireland setting are the Northern Ireland Protestant Boys who have a free school meal entitlement with only 19.7% achieving at least 5 good GCSE grades. In 2001 a review was undertaken [14], to investigate the gender gap and explore measures to reduce the levels of underachievement amongst boys within the education system. The Northern Ireland Audit Office [12] and the DENI [4] had also highlighted the underachievement of boys in their investigations although specific recommendations to improve the underperformance highlighted were not given. More recently in 2010, EURYDICE [7] revisited gender differences and concluded that boys' underachievement continue to be identified in the research. They also highlighted that solutions to this problem continually adopt a generalist approach, rather than a targeted one.

One of the most recent produced by the Community Relations Council during 2014 [2] identified that only Roma and Traveller children are performing lower than NI protestant boys from low income households (FSME), in marked contrast to the fact 77.5% of Catholic girls from higher income households (non FSME) that are among the highest achievers. The Northern Ireland household income divide in school educational achievement is stark when depicted in Figure 2. From low income families (entitled to free school meals) Protestant Boys (19.7%) & Girls (33.2%) and Catholic Boys

(32.4%) & Girls (43.8%) are below the 50% mark, whereas their higher income equivalents (not entitled to free school meals) are all above: Protestant Boys (58.6%) & Girls (71.8%) and Catholic Boys (64.5%) & Girls (76.7%).
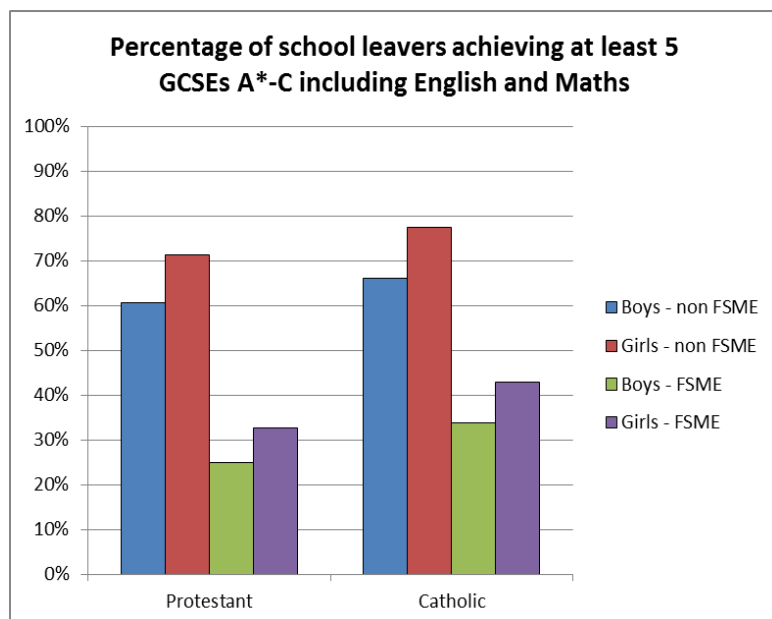

Figure 2. Attainment Gaps in Northern Ireland

3   WIDENING ACCESS THROUGH TARGETING TEACHER PARTICIPATION

Ulster University's Corporate Plan (2012-2016) [19] outlined its approach to widening access and participation (WA&P) in line with the vision of the higher Education Strategy for Northern Ireland. Its aim is to "Permeate the institution and reach beyond the walls of the University, to schools/colleges, workplaces, communities and individuals through a wide range of ambitious widening access activities." [19]

The economic impact of the IT sector in Northern Ireland is thriving, yet it has been identified that there is a severe shortage of software engineers to fill the ever increasing number of positions [6]. In this Widening access project the team at Ulster University developed a module entitled Technology Enhanced Learning for Computer Science Education (TEL4CSE). Its aim is to 'teach the teachers' the skills and knowhow to effectively engage those identified at the lower end of the achievement table. The course focused on introducing the teachers to hardware that could be physically interacted with by students and to introduce programming in a fun and interactive way to them. Raspberry Pi, Arduino, Lego Mindstorms and Quadcopters were selected as the tools as it was felt that lower achieving males would engage with these tools better than some alternatives.

Multiple sessions of the module entitled Technology Enhanced Learning for Computer Science Education ran over the 2013/2014 academic year. The primary objective was to engage with as many teachers from high schools as possible as they typically have more pupils from the lower end of the achievement rankings, although any remaining places were made available to teachers from grammar schools and colleges. The breakdown of the participating schools is illustrated in Figure 3, consisting of Grammar schools, High Schools and Colleges[1].

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[1] Colleges are Secondary (non-grammar) schools providing a traditional 6th form option for eligible pupils
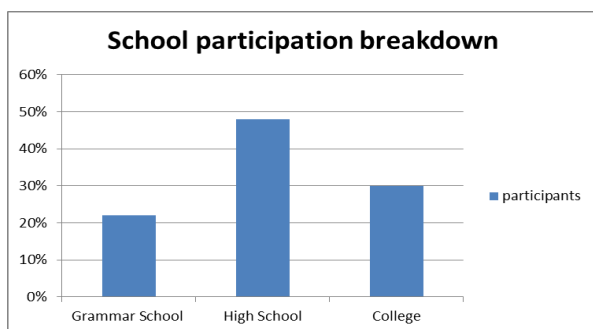
Figure 3. Percentage of participating schools by type

Age	% of participants
21-30	13%
31-40	39%
41-50	35%
51-60	13%

Figure 4. Percentage of participants by age range

It was established that 74% of the teachers who completed the module were female and 26% male. Figure 4 presents their age range. Despite the requirement of newly qualified teachers to complete a plan of continious professional development, the marjority of participants were found to be in the 31-40 age band. This may indicate that more experienced teachers felt a requirement to update their knowledge of emerging technologies.

4   PARTICIPANT FEEDBACK AND RESULTS

Prior to each session participants were asked a number of questions relating to their use of and opinions of Technology Enhanced Learning tools. A number of these questions were included in a post course evaluation with an aim to establish if the understanding and opinions of TEL had been altered as result of their participation in the course and the knowledge of the tools and TEL evolved. The questions that were asked both *pre* and *post* course were as follows:

- What are the factors in encouraging the development of TEL and their relative level of importance?

- Do you agree that there is value in utilising these specific technologies to introduce or develop programming skills for students within your school?

- Which TEL tools are currently utilised as part of your ICT/CS curriculum for introducing programming and to what extent were they used?

- What do you perceive as being the barriers to the development and promotion of TEL tools within your school over the next 5 years?

The participating teachers were asked a range of factors in encouraging the development of TEL. The factors on offer were as follows

1. Availability of support staff
2. Senior management support
3. Availability and access to required tools
4. Availability of school committees to encourage development
5. Peer support
6. Support from suppliers
7. Availability of recognition awards for staff

Figure 5 and Figure 6 depict the pre and post course results. The most significant finding what the shift in the teachers feeling pre to post course, in 'support from suppliers'. Pre course only 18% felt that support from suppliers was 'very important', post course this increased to 44%.
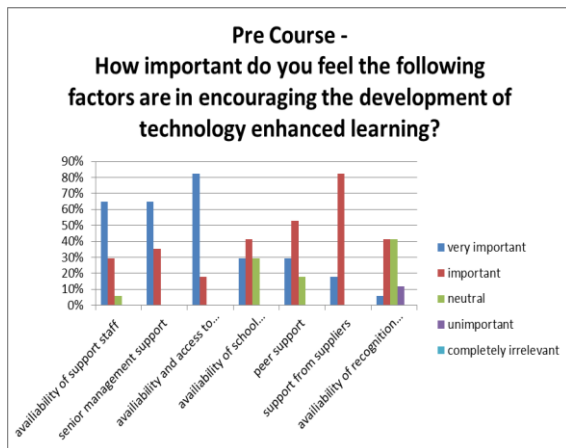
Figure 5. Pre Course feelings towards factors encouraging development of TEL
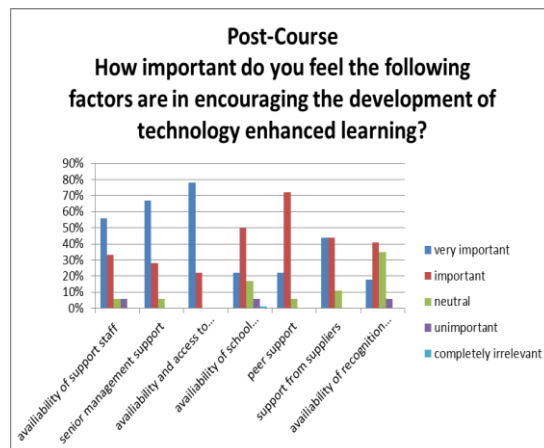

Figure 6. Post Course feelings towards factors encouraging development of TEL

The opinions of teachers and their perceptions of the value of the TEL tools being explored was also measured and the findings are illustrated in Figure 7 and Figure 8. The aim of this question was to establish if their view shifted as their knowledge and understanding of the tools increased. Their perception shifted significantly towards all of the tools. For Arduino, Raspberry Pi and Quadcopter opinion increased favourably, with an increase of over 10% in strongly agreeing that there is value using those specific technologies. Despite there being a decrease for Lego Mindstorms for teachers *strongly agreeing* the value in its utilisation, 100% of respondents *agreed* or *strongly agreed* that there was value post course, compared to only 69% pre course.
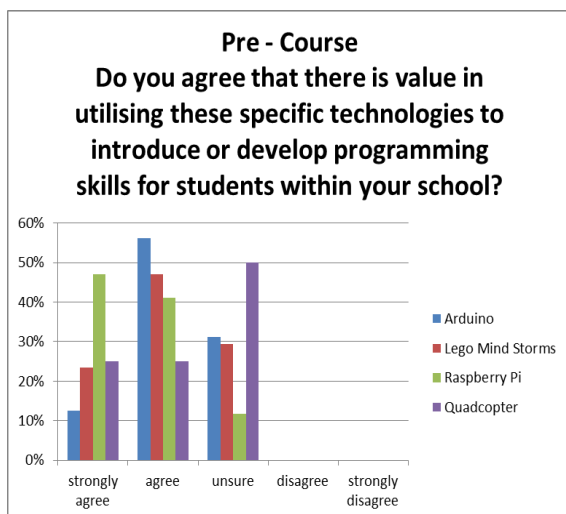

Figure 7. Pre Course views on the value in using the TEL tools in schools
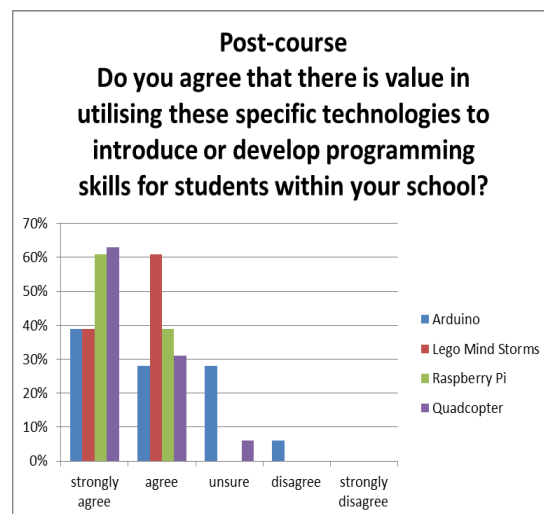

Figure 8. Post Course views on the value in using the TEL tools in schools

When asked about the extent of their current use of TEL, none of the teachers both pre and post course indictaed that they used the 4 tools 'always' or 'most of the time'. Findings as depicted in Figure 9 and Figure 10, show there was however a change in the 'sometimes' use of Lego Mindstorms and Raspberry Pi's use pre and post course. Post course results indicated an increase in current use from 13% to 24% in Lego Mindstorms and an increase from 7% to 28% in the use of the Raspberry Pi's. This may indicate that some teachers began using the tools at their schools during the course itself.
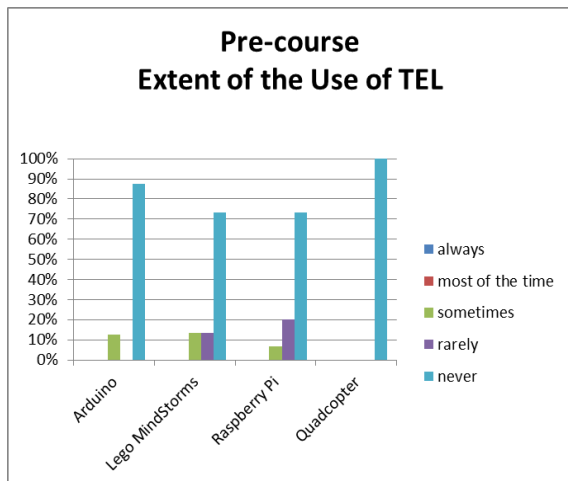
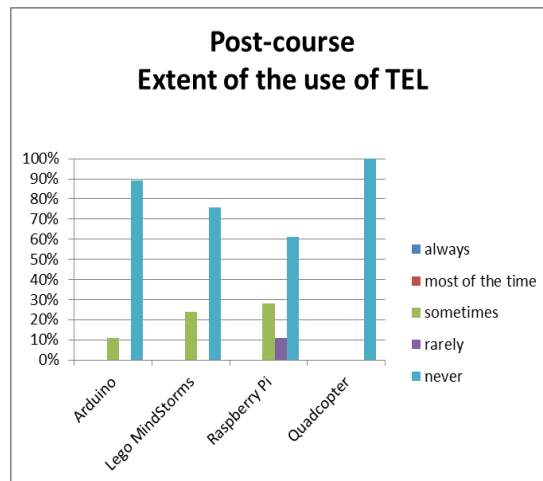**Figure 9. Pre Course extent of the use of TEL in participating schools**

Figure 10. Past Course extent of the use of TEL in participating schools

Figure 11 shows combined pre and post course results when teachers where asked about the barriers to the development and promotion of TEL tools within their schools over the next 5 years. There were significant shifts in the pre and post test perceptions. 'Lack of time' dropped by almost 30% once the course was completed indicating that it may not be as time consuming as originally thought to become familiar with the tools or promoting their benefits to their peers. 'Lack of funds' however significantly increased from 35% to 72%, as an understanding of not just the cost of the hardware itself but add-ons, licence fees, and perhaps the desire to have enough of the equipment for larger groups or entire classes to use productively.
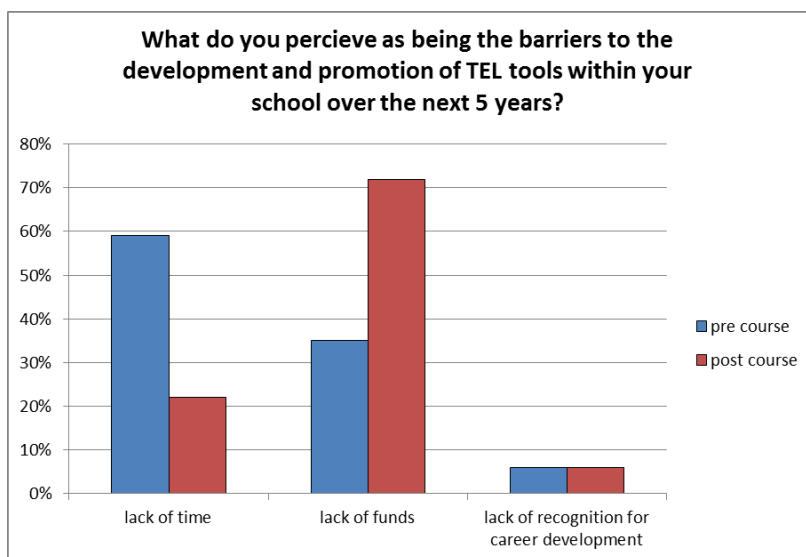

Figure 11. Barriers to development and promotion of TEL

Each participant was required to create and maintain a blog as part of their module assessment. A range of quantative feedback was obtained from these blogs. A selection highlighting the teachers enjoyment and appreciation for the course is provided below.

"What excited me about this idea was the opportunity for cross-curricular Technology Enhanced Learning. The main aim of this course is to attempt to encourage young people to take up programming. I believe the key to this success is to ensure that the Technology can be adapted across a wide range of subjects, thus targeting a greater audience." - *Laura*

"Overall I have found the Taster sessions very illuminating and I feel inspired to take on board several of the technologies and integrate them into our lessons." - *David*

"As a result of this course I will now be able to make use of the 5 Raspberry Pi's that we were awarded after our participation in the worldwide Hour of Code event." - *Ruth*

"It has been a great taster session and has given me the confidence to try out some of these technologies. The only problem is that without the equipment it will be hard to get the school to see the value in investing the money before they have a good grasp of the advantages of this approach." – Sharon

5   CONCLUSIONS

Ulster University and its widening access and participation initiative has been shown to be a success within the Faculty of Computing and Engineering. Both quantitative and qualitative data illustrates not only the level of success but the increased enthusiasm for new technologies and the demand for CPD opportunities to enable teachers to effectively utilise these tools as a part of their curriculum especially in their efforts to improve pupils learning in the lower achievement categories. Participants have agreed to be contacted at intervals over the next 2 years to monitor their use of the tools explored in this course. The second instance of the course reported here has positive comparable results with the first instance [16]. We have since developed further CPD modules which are ongoing, based on advanced use of these tools as a result of the feedback obtained. We are confident that a long term relationship has now been established and that it will expand even further with the STEM teachers of Northern Ireland with a shared vision to improve the overall student learning experience and achievement, particularly in lower performing social groups.

6   ACKNOWLEDGEMENTS

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