Technology Enhanced Learning for Computer Science Education:
A regional STEM Widening Access Case Study

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Abstract— **The paper details a regional widening access STEM initiative in utilizing computing programming for RaspberryPI, Arduino, Lego Mindstorms and Quadcopters 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 "Teach The Teachers" approach and their views of Technology Enhanced Learning for Computer Science Education before and after the CPD course.**

Keywords- STEM (Science, Technology, Engineering & Mathematics) initiatives

I. INTRODUCTION

Computers and the internet have impacted on many aspects of our daily lives, including efforts to improve teaching and learning (Hechter & Vermette, 2011; Sandholtz, Ringstaff, & Dwyer, 1997; Voogt, Tilya, & van den Akker, 2009; Williams, Linn, Ammon, & Gearheart, 2004). It has been argued that teachers have not been provided with sufficient support that extends past learning specific technology skills (Llorens, Sllanova, & Grau, 2002; Tang & Austin, 2009). The Northern Ireland Education System has often been the subject of social and political research (Goeke-Morey et al., 2012; Hewstone, Cairns, Voci, Hamberger, & Niens, 2006; Niens & Cairns, 2005). This paper reports on the beginnings of a longer term project to study the use of technology to enhance and motivate in Computer Science Education the learning experience of under-achieving classes in Northern Ireland (NI).

II. NORTHERN IRELAND EDUCATIONAL ENVIRONMENT

Northern Ireland is renowned for continuously achieving top of the educational performance league tables in terms of GCSE (16 year olds) and GCE (18 year olds) within the UK (Community Relations Council April 2014, DENI 2011/12 & National Pupil Database and Key Stage 4 attainment data 2011/12). Yet at the other end of the scale it also has amongst the worst results for under achievement of school leavers. Regionally within the UK, Northern Ireland had retained the Grammar and Secondary Schools system with academic selection at 11 years old until recently. Recently, local Government removed selection but the grammar sector are still using test operated independently by either or both of the Association for Quality Education and the Post Primary Transfer Consortium. The rest of the UK had moved to a non-selection comprehensive system in the mid 1970s. Also, for the most part, Northern Ireland has a religious segregated education system. Table 1 depicts some of the data points in a top 40 comparison between England and Northern Ireland (Community Relations Council April 2014, DENI 2011/12 & National Pupil Database and Key Stage 4 attainment data 2011/12) where achievement is measure at obtaining five good GCSE grades. Free School Meal Entitlement (FSME) vs non-entitlement (non-FSME) was used as a measure to indicate between poorer and better off backgrounds. The notable differences in the full data set is the gender gap and between those that have and have not.

A review was produced in 2001 (Northern Ireland Assembly Research and Library Service 2001), specifically discussing the gender gap and the prevention of underachievement amongst boys within the Northern Ireland education system. Since then there have been several reports and investigations on the topic of the underperformance of boys, discussing topics from Literacy and Numeracy to Community Background. More recently in 2010, (EURYDICE, 2010) 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.

The most recent study by the Community Relations Council (2014) further identified that only Roma and Traveller children are getting poorer results than NI protestant boys from poorer backgrounds (Figure 1), in marked contrast to the fact 76% of Catholic girls from better off backgrounds are among the highest achievers. In fact in Northern Ireland the rich-poor divide in school educational achievement is stark when depicted in Figure 1. Poorer (entitle to free school meals) Protestant Boys (19.7%) & Girls (32.4%) and Catholic Boys (33.2%) & Girls (43.8%) are below the 50% mark, whereas their richer equivalents (not entitled to free school meals) are all above (richer Protestant Boys (58.6%) & Girls (71.8%) and Catholic Boys (64.5%) & Girls (76.7 %)).

Attainment gaps in England and Northern Ireland (Combined Ranked Data)		
Rank	Category	Percentage achieving at least five good GCSE grades
1st	Chinese Girls Non-FSME (Free School Meal Entitlement)	81.4
2nd	NI Catholic Girls - Non FSME	76.7
3rd	Chinese	76.4
6th	NI Protestant Girls - Non FSME	71.8
10th	Irish (in England)	66.9
11th	NI Catholic Boys - Non FSME	64.5
16th	Northern Ireland - All students	62
20th	All students - England	58.8
21st	NI Protestant Boys - Non FSME	58.6
28th	Northern Ireland Ethnic Minority	52.7
32nd	Northern Ireland Catholic Girls - FSME	43.8
35th	NI Catholic Boys - FSME	33.2
36th	NI Protestant Girls- FSME	32.4
37th	White Boys	26.9
38th	NI Protestant Boys - FSME	19.7
39th	Traveller of Irish Heritage	16.7
40th	Gypsy / Roma	9.7

Table 1 Attainment gaps in England and Northern Ireland (summary points from the top 40) [Community Relations Council 2014]
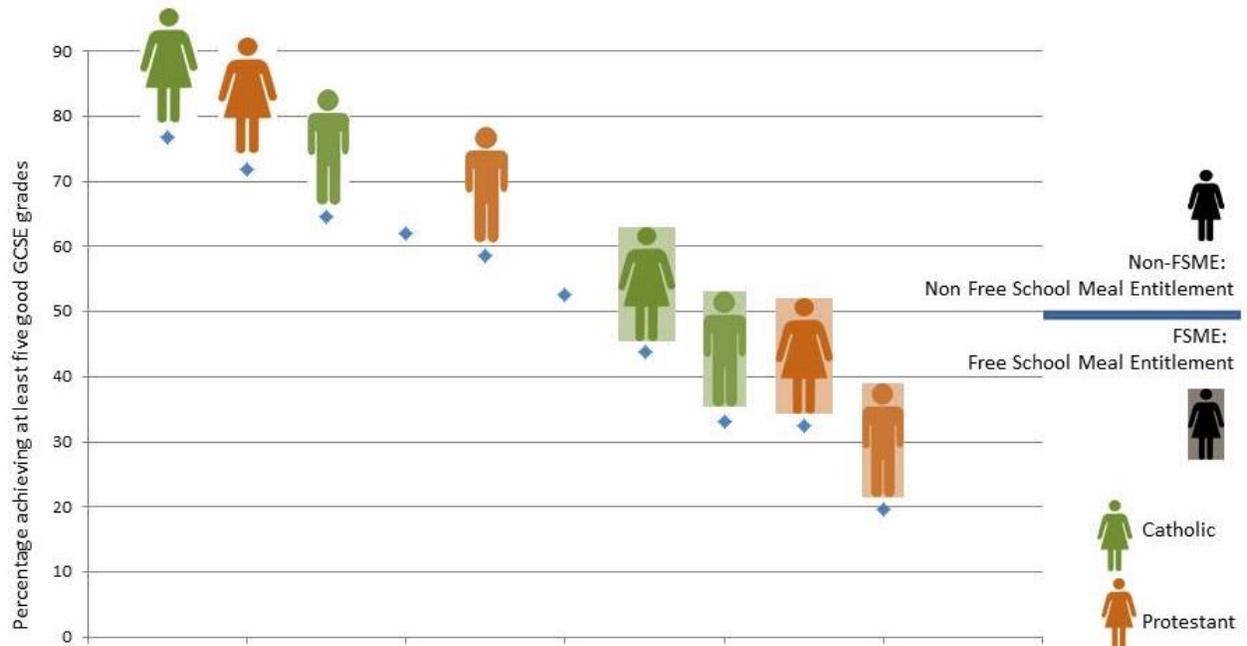

Figure 1 Attainment Gaps in Northern Ireland

III. WIDENING ACCESS THROUGH TARGETED TEACHER PARTICIPATION ON SPECIALLY DESIGNED CPD COURSES.

As a part of the University of Ulster's Widening Access initiative the University of Ulster values and corporate plan include (University of Ulster 2011):

- Raising aspirations and making our programmes accessible to those who have the capacity to benefit;
- Equality, diversity and inclusiveness;

Economically, the Northern Ireland Software sector is flourishing, yet it has a shortage of software engineers. In this widening access project, in an attempt to address the gender and religion gaps through targeting schools from the categories at the lower end of the achievement table, the team developed a CPD Teach the Teachers 'Technology Enhanced Learning for Computer Science Education' course. The course focused on introducing programming utilizing "fun" oriented hardware; namely RaspberryPi, Arduino, Lego Mindstorms and Quadcopters, as it was felt these would better engage the lower achieving male.

IV. PARTICIPATING TEACHER FEEDBACK AND RESULTS

Prior to the commencement of the course participants were asked a series of questions. Some of these questions were repeated in a post course survey with an aim of establishing if their understanding and views of Technology Enhance Learning (TEL) had evolved as their knowledge and experience of TEL increased. Questions were focussed on the following areas:

- Which TEL tools were currently utilised as part of their ICT/CS curriculum for introducing programming and to what extent were they used?
- What were the factors in encouraging the development of TEL and their relative level of importance?
- What are the perceived barriers to the development and promotion of TEL tools within the next 5 years?
- What was the teachers' motivation for attending the course?

Teachers were asked about the level of use of the four main TEL tools that were to be included in the TEL4CSE course. Pre and post results varied significantly in three of the four technologies showing an increase in use in post survey results.

Findings illustrated in Figure 2 & Figure 3 show that in the use of Arduino, Lego Mind Storms and Raspberry Pi the extent of use increased in the instance 'sometimes' by a minimum of 20% form 0% in each tool.

In terms of the teachers' motivation for attending the course (Figure 4 & Figure 5), the pre to post figures for 'yes plans are already in place…' jumped from 22% to 30%; 'Yes been discussed…' jumped from 33% to 40% while the two no options dropped from 33% to 20% and 11% to 10%. From qualitative feedback (see below) it was evident in their blogs that after each of the four evenings of the course the teachers were returning to the school discussing TEL with their colleagues and planning how to integrate it into the curriculum.

In terms of the pre and post view on important factors for encouraging TEL (Figure 6 & Figure 7) only peer support dramatically changed very important dropped 13% while important increased 14% and more reliance on support from suppliers (a 7% swing from important to very important). This may indicate the teachers were becoming more confident in their own ability with the technology due to the course and would rely less on peers while seeing support of suppliers as more critical.

The teachers' perception of barriers to the development and promotion of TEL (Figure 8 & Figure 9) within their school also changed from pre to post course, for example there was a fall from 44% to 20% for lack of time (perhaps indicating again more confidence, in that it would not be as time consuming after the introduction provided by course) while lack of funds increased from 44% to 70%. This obviously became a concern after the course, and from verbal discussion during (and online blogging) it was evident the teachers wanted the equipment – so their focus may have changed to how to fund it. Lack of recognition for career development drop from 11% to 0%, while lack of opportunities to learn about the tools rose from 0% to 10%., perhaps indicating teachers wanted to learn more.

In addition to the quantitative data above some qualitative feedback that was expressed in the teachers' blogs follows:

"Just home from our first session in UUJ. Already buzzing with ideas for using simple programming apps with lower ability first years, and maybe introducing some Raspberry Pi programming with a small Yr10 group in the very near future.....Also, really looking forward to trying out the drones...... Have a feeling that our STEM team may be "persuaded" to purchase this nifty piece of kit." - Carrie

"Overall I have found this course has been quite inspiring and I cannot wait to get back into school to develop our schemes of work to try to incorporate these new technologies. If we can fire up the kids with these 'toys' I think we could get a real interest in Computer Science and that is where I want to start before I would even touch the A Level. Get them young and bring the interest through the school with them, that way when they get to A level they will already have the bug!!" - Patricia

"The work with the Lego Mindstorm kit was especially interesting and I can really see how this kind of kit would appeal to students in school, especially boys. Once again I was especially grateful for the opportunity to work with this kit in a supported environment." - Margaret

V. CONCLUSION

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.

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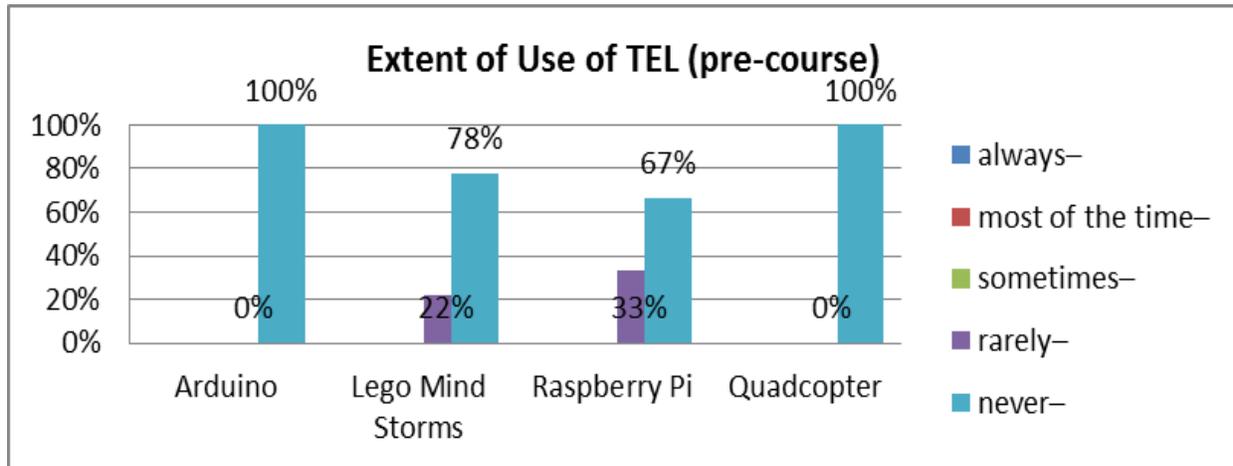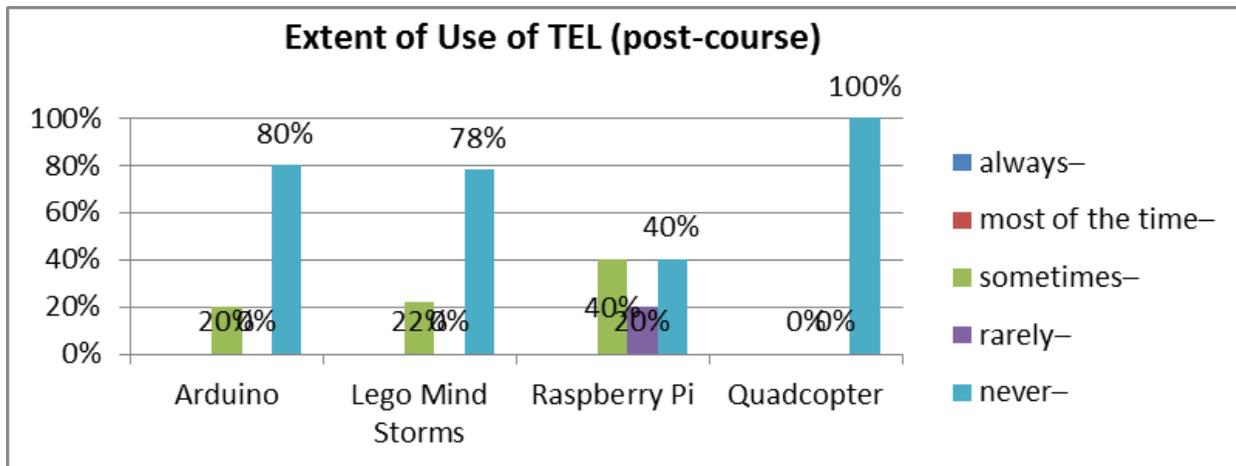
Figure 2 Pre-course – extent of use of TEL in School
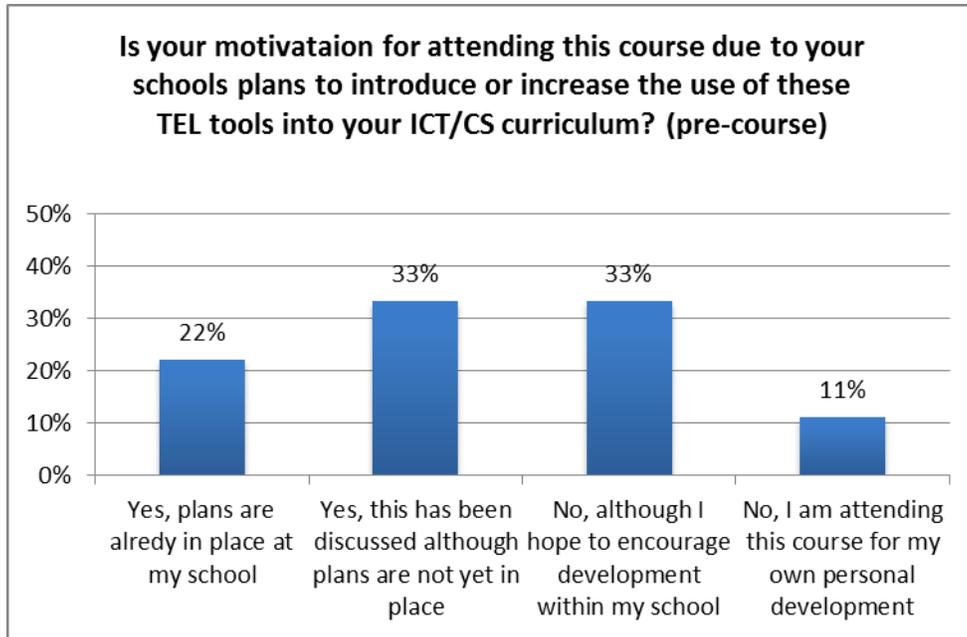

Figure 3 Post-course extent of use of TEL
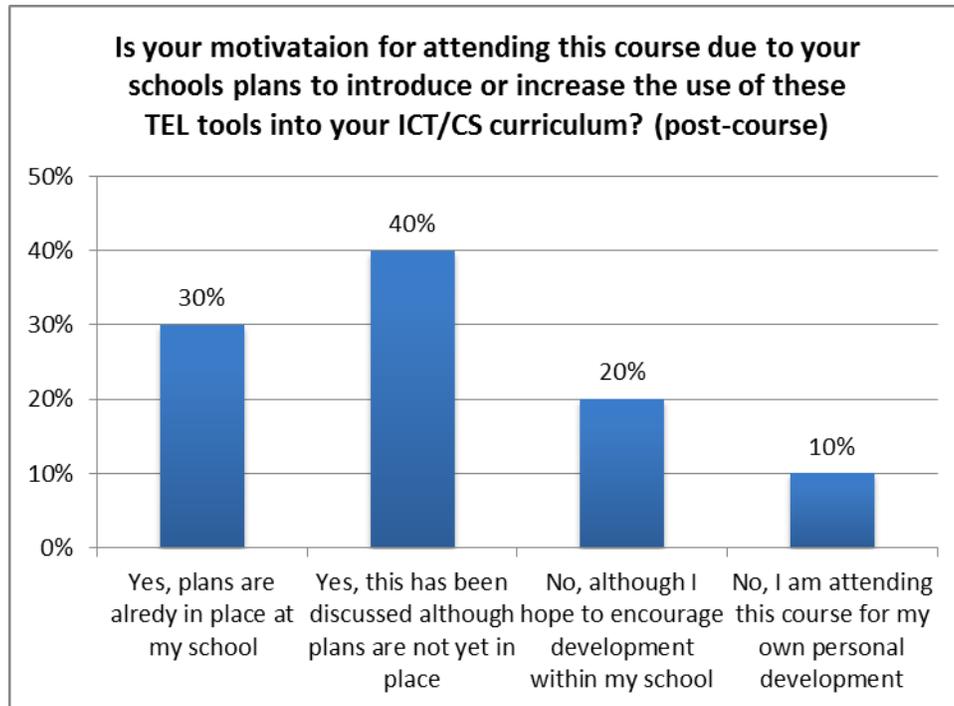
Figure 4   Pre-course motivation to use TEL
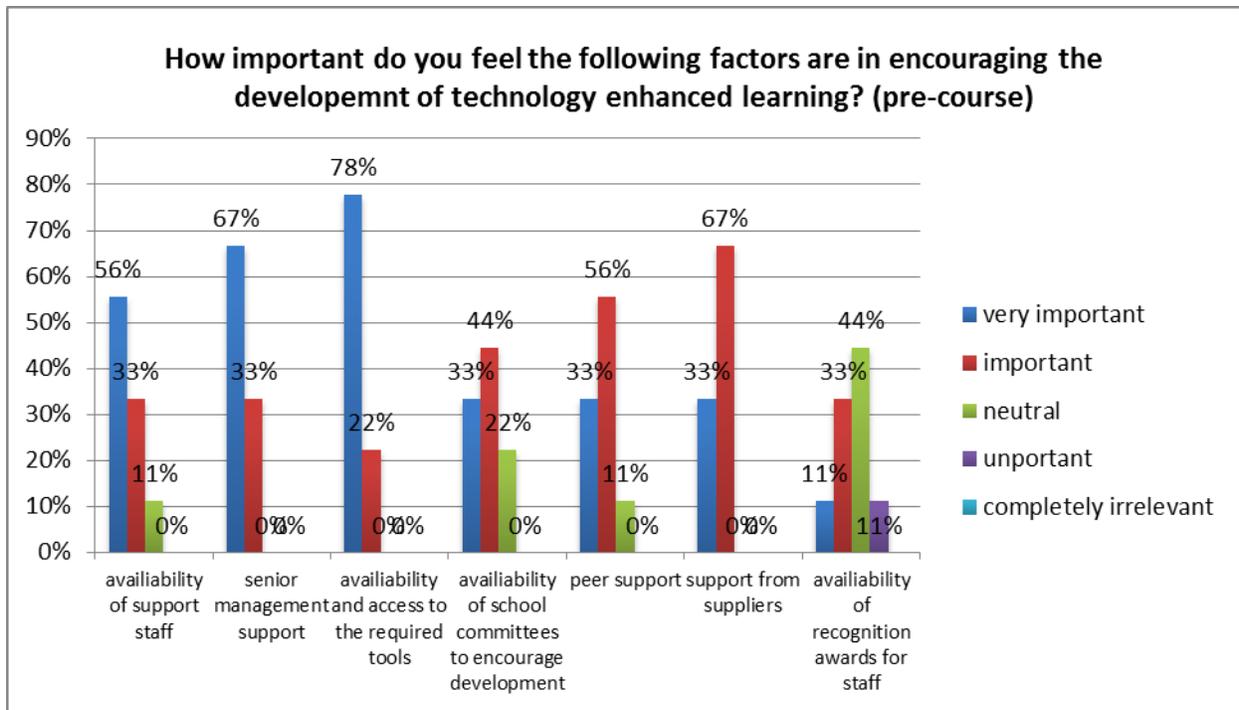

Figure 5 Post-course motivation to use TEL
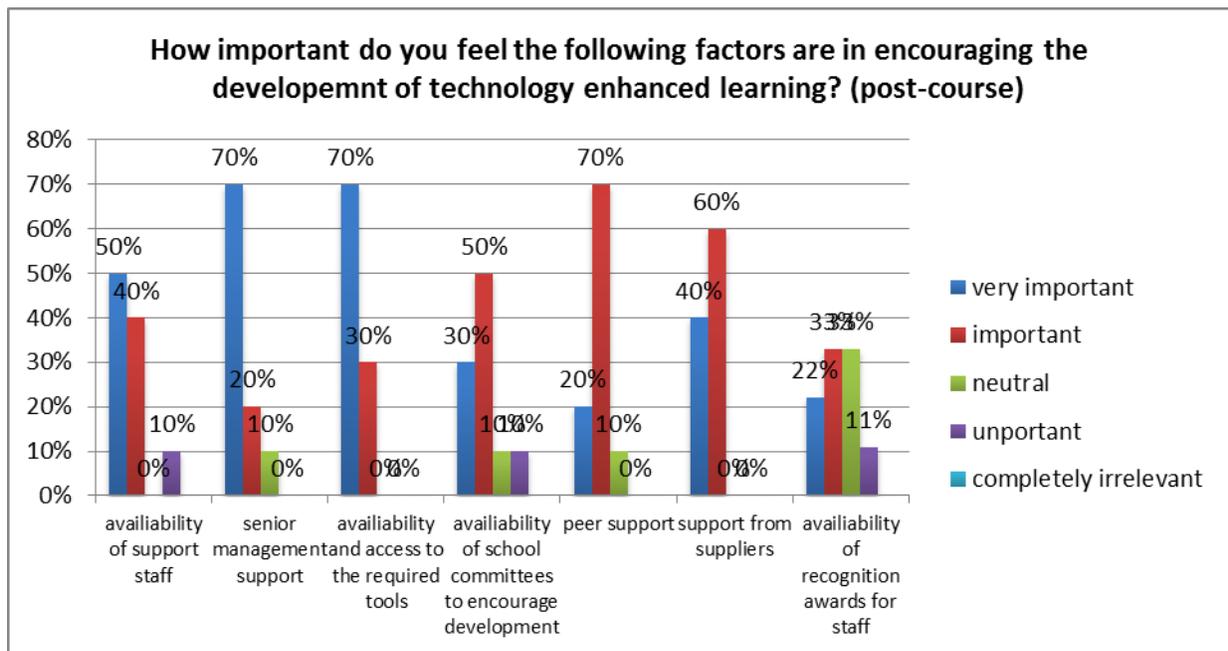
Figure 6 Pre-course Factors influencing developing TEL
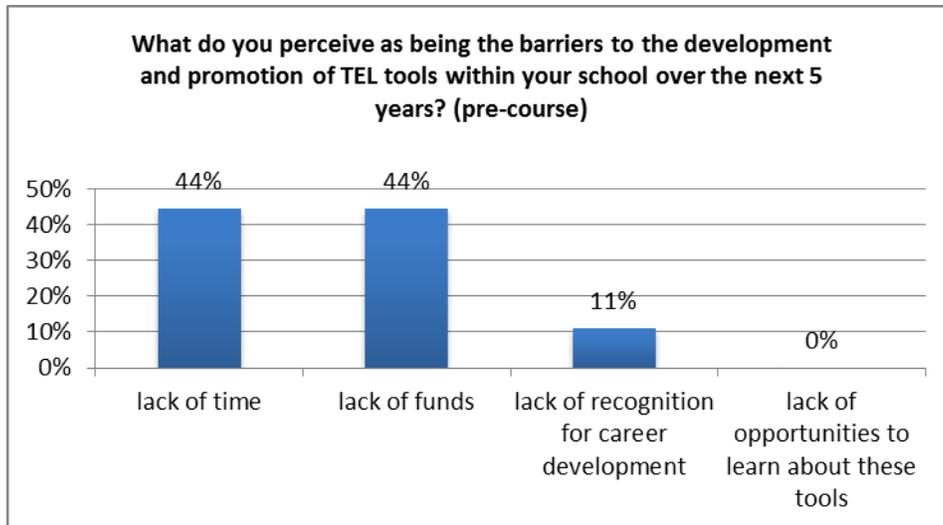

Figure 7 Post-course Factors influencing developing TEL

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

	lack of time	lack of funds	lack of recognition for career development	lack of opportunities to learn about these tools
	44%	44%	11%	0%

Figure 8 Pre-course Barriers to developing TEL

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

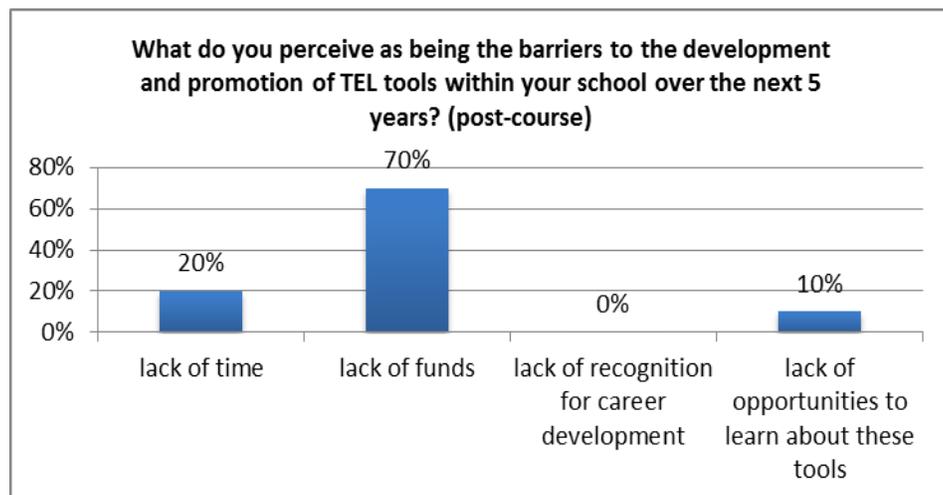|	lack of time	lack of funds	lack of recognition for career development	lack of opportunities to learn about these tools
	20%	70%	0%	10%

Figure 9 Post-course Barriers to developing TEL