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Grand challenges for the UK: Upskilling teachers to teach Computer Science within the Secondary Curriculum

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ABSTRACT

This paper reports on work in progress in the UK, researching models of continuing professional development (CPD) for ICT teachers needing to teach Computer Science in response to recent changes to education policy in the UK. We currently work with many teachers who either do not have an appropriate academic background to teach Computer Science, or who do and have not utilised it in the classroom due to the curriculum in place in the UK for the last fifteen years. In this paper, we outline educational policy changes in the UK that have affected teachers in ICT and Computer Science; we describe a range of models and discuss the role that local and national initiatives can play in developing a hybrid model of transformational CPD, briefly reporting on our initial findings to date.

Categories and Subject Descriptors

K.3.2 [Computers & Education]: Computers and Information Science Education- *Computer Science Education*

Keywords

Computer Science Education, Continuing Professional Development, CPD, K-12 Curriculum, High School

1. INTRODUCTION

Recent curriculum changes in the UK have meant that there is a huge demand for continuing professional development (CPD)¹ in Computer Science (CS) and for more focus on CS in pre-service training (initial teacher training) for

¹In this paper the term *continuing professional development* will be used as equivalent to the term *in-service training*

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ICT teachers. Finding ways to support the re-skilling of many teachers in the UK to be able to teach CS in school is of interest to universities, industry, government departments and teacher associations. This paper reports on the work being done to investigate models of CPD that will meet the needs of teachers who wish, or are required to, teach GCSE² CS in their schools, and do not have sufficient up-to-date subject knowledge. Much research has been done on a variety of models for building and sustaining an effective and confident teaching workforce. In this paper, we consider the context of CS Education CPD in the UK, and draw on the framework of CPD outlined by Aileen Kennedy [9], proposing a range of strategies that would lead to transformative CPD in the area of CS in schools.

2. BACKGROUND TO CS EDUCATION IN SCHOOL IN THE UK

There have been significant changes to compulsory education in the UK over the last 25 years, which resulted over time in CS essentially disappearing as a curriculum subject for under-16 year olds and being replaced by Information & Communication Technology (ICT) [4]. However this situation in the UK is currently being reversed. Computing At School (CAS) is an organisation formed in 2009, to promote CS education in the UK and support CS teachers. Its efforts have been augmented by the effect of a lecture by Eric Schmidt, Executive Chairman of Google, criticising the lack of computer science education in UK schools [13], and also a report by The Royal Society describing the teaching of computer science in many schools as *“highly unsatisfactory”* [14, p.1]. The Royal Society report’s recommendations included:

- increasing the number of teachers trained to teach Computer Science
- improving in-service training for teachers
- providing more technical resources for schools.

The UK government subsequently announced that the National Curriculum for ICT in England was to be disappplied from September 2012, removing a prescriptive programme of study and facilitating the teaching of more Computer Sci-

²GCSE is a qualification in the UK that is taken at age 16. GCSE Computing and CS have just been re-introduced in the UK after approximately 15 years

ence in school. Whilst this is a hugely positive shift in education policy for the UK, and it is apparent that there are many schools willing to offer CS to students, there are many teachers who feel they do not have the skills and an urgent need for more CPD for schools in this area.

3. MODELS OF CPD

There is a considerable corpus of research on CPD spanning several decades, including hundreds of individual studies of different types of CPD and the evaluation of CPD. Teachers can participate in many hours of training or other prescribed CPD in school or college and take up external courses in order to improve their own skills in teaching and learning but sometimes actual change is difficult to achieve, particularly as “*change is a gradual and difficult process for teachers*” [7]. As Bell & Gilbert report [2], sometimes even the most well-intentioned efforts to change do not succeed:

“...many teachers, even after attending an in-service course, for example, feel unable to use the new teaching activities, curriculum materials or content knowledge to improve the learning of their students ... Many teachers are aware of this pattern and feel frustrated in their attempts to change” [2, p.9].

A particularly effective form of CPD is collaborative, which can be defined as “*teachers working together on a sustained basis and/or teachers working with LEA or HEI or other professional colleagues*” [3]. In all but one of 266 studies of collaborative CPD reviewed by Cordingley, Bell, Rundell & Evans [3] there was a definite teacher improvement as a result.

Kennedy [9] considers a wide range of models of CPD and proposes a framework through which they can be analysed. She defines nine different categories of CPD and places them on a spectrum in terms of their “*potential capacity for transformative practice and professional autonomy*” [9, p.236].

Kennedy’s nine categories of CPD are as follows:

- Transmissional
 - training
 - award-bearing
 - deficit
 - cascade
- Transitional
 - standards-based
 - coaching/mentoring
 - community of practice
- Transformative
 - action research
 - transformative

There is a notion that the transmissional type of CPD is less successful in facilitating teacher change than those that offer a degree of teacher autonomy. Fraser, Kennedy, Reid & McKinney posit that “*Formal planned opportunities, which are essentially transmissive, are unlikely to result in transformative professional learning for teachers, because they attend primarily to occupational aspects of professional learning*” [6, p165]. In contrast, they consider that transformational learning is more likely to take place where the opportunities for learning attend to the personal and social aspect of professional learning [6]. This will be an important factor in establishing an effective model of CPD in the UK.

Another category of CPD is the community of practice, where there is a joint enterprise, mutuality and a shared repertoire of communal resources [15]. In practice, teachers working together towards a common goal, for example, implementing a new strategy, who share their experiences, talk the same language, and are willing to learn from one another, can be said to be a community of practice.

Being mentored or coached is another way that a teacher can develop professionally. With a peer coaching model [8], teachers of equal status work together; in contrast, mentoring assumes that the mentor has a higher level of expertise than the mentee [5]. Mentoring may be less likely to be transformative than coaching, whereas the coaching experience is designed such that the coachee is able to solve their own problems and thus become empowered to be able to effect change.

As Lipowski, Jorde, Prenzel & Seidel report [10], there is also a need for institutional support within CPD. In a recent study, experts from a range of countries report an urgent need to “*reform existing insitutional conditions, including existing cooperation or coordination structures between institutions involved in the TPD system*” [10, p694]. The impact of effective CPD can be directly linked to school improvement. Opfer and Pedder report [12] that teachers in the highest performing schools reported participating in professional learning activities with higher levels of effectiveness: they were of longer duration, were more active, and teachers shared what they had learned with colleagues more often. This demonstrates that achieving good-quality CPD can affect the performance of the school. An Ofsted [11]³ report on professional development (PD) supports this by stating that the weakest link in the chain is the way the schools evaluate the effectiveness of their PD activities.

In terms of the particular case of CPD for CS teachers, particularly relevant is the balance between subject matter knowledge (SMK) and pedagogical content knowledge (PCK) as described in a recent review by Armoni [1]. Armoni emphasises the importance of learning how to teach CS as well as a teacher’s own understanding of the subject and we hope to incorporate this work in our study, as well as the focus on a constructivist approach to the preparation of teachers in this area. However, our study will consider preparation of in-service teachers as well as pre-service teachers in the rapidly changing curriculum in the UK.

4. RESEARCH QUESTIONS

This paper reports on the beginning of a study to investigate the nature of the CPD required to facilitate more Computer Science in school in the UK (particularly England and Wales). The research questions addressed at the beginning of this study are as follows:

- To what extent teachers without CS-related degrees can be trained and given the confidence to be able to teach CS in the curriculum up to age 16 (GCSE level)?
- What are the effective models of teachers’ CPD and to what extent they can be applied to CS?
- How does CPD for teachers in CS impact on improved provision of courses in England and Wales, and correspondingly on pupil learning in this area?

There are many emerging initiatives in the UK around the

³Office for Standards in Education, Children’s Services and Skills

first two questions. We maintain that what is needed is to be able to address the third question, the impact on pupils. In aiming for an up-skilling of teachers, the transformation will only be achieved if pupil learning is enhanced and there are increased opportunities for pupils.

5. TRANSFORMATIVE CPD FOR SECONDARY TEACHERS IN THE UK

A successful model of CPD can be bottom-up, top-down, or a combination of both. In the UK at present there are several initiatives arising from individual institutions becoming aware of local need for professional development. In addition subject associations can have a role to play in establishing a national framework for up-skilling the teaching workforce.

5.1 Local initiatives: training

An initial study has been carried out using two models of training for ICT teachers wishing to include more CS in their teaching. These courses are taking place at a university in the east of England. There are two approaches to university based training that have been trialled at Anglia Ruskin University by the first and second authors: (i) twilight sessions over a period of 10 weeks, and (ii) intensive courses over a number of days.

The twilight model has been so far aimed at existing teachers who may find it difficult to attend an intensive course as it requires so much time away from school, and the intensive course at trainee teachers who have just finished their initial teacher education. In both approaches the delivery has been by current teachers/teacher educators who have experience in teaching CS in a school environment. It has been assumed that current practitioners are best placed to explain how to deliver this content to students and to avoid overcomplicating the process with unnecessary detail.

5.1.1 Twilight Model

The twilight model involves a 2.5-hour session each week over the course of a 10-week period. Each session is split into 1 hour of CS theory and 1.5 hours of programming. There are no expectations of existing knowledge or skills in either component but there is flexibility to react to the requirements of a particular cohort.

Each theory session focuses on a different part of the CS specification each week. This is delivered through a mix of lectures, practical activities and discussion. Each theory session stands alone and therefore it is possible for teachers to miss some weeks and still gain benefit from attending further sessions without having to make significant investments in time covering missed material. Programming concepts are delivered through a mix of demonstration and paired working. The focus is on getting to the practical programming quickly so that the instructors can support the attendees. Both theory and programming are backed by websites, which contain the material taught during the sessions and supplementary material including video tutorials.

5.1.2 Intensive Courses

Intensive courses are provided over a period of five days where attendees will focus completely on developing the knowledge and skills required to deliver the CS specification. The content is similar to the twilight model intensive model has focused solely on developing programming skills

in attendees as this is an area that many trainees have no experience in. The intensive nature of the course gives attendees the opportunity to focus and practice without other competing demands on their time.

5.1.3 Initial Findings

At the end of the intensive programme, 90% said that they had the skills to teach introductory programming. Teachers commented that: *“The training was brilliant. I feel that I have learnt heaps and this has definitely sparked an interest in computing for me. I’m keen to learn more!”*. Four months later, the attendees were asked if they had used what they had learned on the course. There was a low response but four out of six reported that they were applying the training and one teacher reported: *“It has given me the impetus to drive forward with introduction of GCSE Computing in my school.”*

After the twilight model, the respondents gave similar enthusiastic feedback on their experience of the course, for example: *“My expectations have been exceeded. I’ve learned more about Python than I thought or hoped and the computer science lessons have been very thorough.”*. Teachers were asked to rate their confidence levels before and after the course and the average confidence level rose from 2.9 to 7.7 from the 10-week program. Some teachers did find the course very challenging: *“[I would like] ... more time programming or do this first as by the later time I was really tired and found it more difficult to focus.”*. Attending training after a long teaching day is demanding on teachers.

Whilst there has been very positive feedback from teachers themselves, the trainers’ observations are that some teachers are finding it difficult to fully engage with the course, particularly in the twilight model. Many teachers appear to find it difficult to set aside time to practise programming between sessions and unfortunately this significantly hampers their ability to become competent programmers. Like learning any new skill if it is not practised the knowledge quickly fades.

In terms of the intensive model, the focus is also on getting to practical activity as soon as possible and the concepts are again conveyed through a mix of demonstration and paired working. Since there is no delay between sessions there is little opportunity for knowledge to fade so there is not the same imperative to practise between sessions. Once the course is over the same dangers relating to practice still apply.

Other models of CPD will now be considered which are being initiated by CAS.

5.2 Local initiatives: community of practice

Local hub meetings are held after school for groups of teachers in the areas across the UK to discuss CS teaching issues. Guest speakers are invited to share their own areas of expertise. Typically, hub meetings take place two or three times per year with about 20 to 30 attendees, although this varies. Hubs provide a community of practice for participating teachers where they can discuss issues relating to teaching Computer Science in school and find out about new developments and resources.

5.3 National initiatives: the Network of Excellence

The Network of Computer Science Teaching Excellence is an initiative that has been set up by CAS and BCS Academy

of Computing, the learned society which is dedicated to advancing Computing (CS & IT) as an academic discipline. It is designed to utilise and formalise the hub system set up within CAS, with schools and universities across the country registering to support one another. The ambitious aim of the network is to establish CS teaching in at least 1000 schools by 2015. It is planned that initially one university will support twenty-five secondary schools. Using the university as a central point of reference it is hoped that they will be able to better identify and adapt their support for the needs of the local schools. To make this model sustainable, schools will then support at least one other school.

5.4 National initiatives: the Master Teacher

To support the universities with developing and delivering teacher training materials that meet the needs of local schools, CAS is recruiting Master Teachers to form a local provider team. Master Teachers will work with universities in the Network of Excellence. In the medium term it is hoped that this will create CS departments who are more aware of the needs of local schools and how to meet them as well as a national network of advanced skills teachers in CS. These 'CAS Master teachers' will be responsible for the delivery of CPD to schools in their region working in association with HE and industry. The structure and content of the courses can be determined by the local provider team but will be influenced by the CAS Curriculum, and will point to suitable resources on the CAS Community site. Each resource would be mapped to the points of study in the CAS Curriculum and in the long term ensure curriculum coverage.

6. DISCUSSION/NEXT STEPS

Using Kennedy (2005) classification we have a series of different models that are planned to be used in the UK:

- National
 - Cascade – the Network of Excellence
 - Coaching/mentoring – the Master Teacher model
- Local
 - Training/deficit courses – subject-knowledge and pedagogy provided by universities
 - Community of Practice – local CAS hubs supporting a network of teachers

Together, as a hybrid collection, we posit that these form a transformational model of CPD.

This range of models of CPD has been planned to tackle a national emerging situation in teacher education in England and Wales. An online questionnaire has been designed to collate the perceived needs of ICT teachers in terms of their preparation to teach CS in secondary school. This will enable us to answer the first research question above. The next focus in this research study will be on the third research question and on developing a research instrument to measure the impact of the professional development on both pupils, teachers and schools. The initiatives outlined in this paper and the impact of the various models will be evaluated.

7. CONCLUSION

It cannot be assumed that providing training or facilitating professional development activities for teachers will necessarily bring about the transformation of Computer Science

education in the UK that we require. There is a need in the UK for teachers to have confidence at an academic level to teach Computer Science; however professional development relating to pedagogy must not be ignored. The question as to who is responsible for up-skilling the teachers is increasingly important. Local initiatives may be most valued by teachers as they create networks and interpersonal relationships to support teachers. A local approach, however, can be ad-hoc and areas of the country will be neglected.

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