Making Computing Interesting to School Students: Teachers’ Perspectives

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ABSTRACT
It is widely agreed that there is a need to excite more school students about computing. Considering teachers’ views about student engagement is important to securing their support for any solution. We therefore present the results of a qualitative, questionnaire-based study on teachers’ perceptions of the best ways to make the subject interesting. From 115 responses by UK computing teachers emerged a range of themes about the issues they felt were most important. We found that whilst their views reflected a range of approaches that are widely promoted in the literature and in national initiatives, there were also disconnects between teachers’ views and wider discourses. Based on the results, we give specific recommendations for areas where more should be done to support teachers in making computing interesting to school students. Academics should do more to engage with teachers, especially if they wish to introduce deep computing principles in schools. Teachers expressed an interest in computing clubs in schools, but a strong support network for them is still needed. This may be an opportunity for businesses and universities to help support teachers.

Categories and Subject Descriptors
K.3.2 [Computers and Education]: Computer and Information Science Education – Computer Science Education

General Terms
Human Factors.

Keywords
recruitment; schools; teachers; pipeline; gender issues; K-12; curriculum; public engagement; girls; geek; universities; survey; fun; programming; clubs; computational thinking; unplugged; cs4fn.

1. INTRODUCTION
The call to enthuse more secondary-age students in computer science has been answered by universities, governments, companies and teachers themselves. In countries around the world a range of excellent initiatives have bloomed, like Scratch [18], CS Unplugged [1], the Computer Science Teachers Association [9] and CS4HS [4]. The UK is home to many such projects – Greenfoot [16], CS Inside [12] and Computing At School (CAS) [8] for example – but despite this, student uptake remains low. The number of students taking computing at A-level (ages 16-18; pre-university schooling) has roughly halved since 2005 [6]. In 2012 the UK education secretary, Michael Gove, said that the ICT (information and communications technology) curriculum was “demotivating and dull” [26] and initiated a complete reform. The overhaul, now underway, of the way British students learn about computing presents a big opportunity to consider how best to enthuse more students.

The authors of this paper run a CS initiative for secondary school students. As part of the evaluation of our initiative, we mailed questionnaires to heads of ICT at secondary schools throughout the UK. In addition to questions evaluating our own work, we asked teachers for their suggestions about how to enthuse more students about computer science. In this paper we present and analyse the teachers’ responses to that question.

We identified a number of strong themes in teachers’ comments, which included discussions of curriculum issues, students’ classroom experience and wider support and engagement. We see teachers’ responses as a potentially important signpost – not only to what teachers feel students want, but also to what teachers want to give them. Because most computer science initiatives for young people (even extra-curricular ones) depend on schools in some way, the buy-in of teachers is essential for success. This has implications for groups like academics who want to have influence on the school computing experience. This paper contributes to the discussion in academia of declining student interest in computing by sharing teachers’ views on possible solutions. In particular we propose a 4-point framework of values that teachers feel are important motivators for students, and recommend that universities engage better with teachers, particularly if academics wish to introduce computing principles, including computational thinking, into schools. We identify a desire by teachers for computing clubs, and recommend that academics and business join forces to support it.
2. BACKGROUND AND RELATED WORK
The typical secondary school student in the UK rarely encounters computer science topics. This is not only due to dwindling numbers in computing classes [6]. The curriculum in the UK tends to focus on ICT training classes rather than CS content [6, 17, 24]. School students complain that ICT is boring and seems to prepare them for jobs they do not want [22]. There is a belief that computing entails little more than learning how to use computers (e.g., using a word processor or spreadsheet) [23]. Students and careers teachers often have an incomplete idea of what CS can involve [12]. Even among first-year university students there is some surprise at the contents of the CS syllabus [19].

A variety of university-driven initiatives such as Greenfoot [16], CS Inside [2, 12] and our own, cs4fn [11], have sought to address the disconnectedness between the pervasive use of the products of computer science technology, particularly by young people, and their lack of knowledge about how they work. These and other ‘excite programs’ [13] also aim to enthuse students about CS more generally, and increase their awareness of the topic, but also in the hope of increasing enrolment onto further CS courses.

The question of improving school computing has also, of course, been addressed by school educators themselves. Brown et al. report on the experience of CAS [6], the membership of which is 85% teachers [5]. The ability of CAS to draw attention to the need for change in school computing has been strengthened by being a conduit for teachers’ opinions. Other work has sought UK teachers’ views on their own CS knowledge [12], CPD [23], aspects of computing and particular teaching tools [17]. The Royal Society’s 2012 report Shut down or restart? [23] contains two interesting case studies looking at teachers’ efforts to enthuse students – particularly younger ones – with computing concepts. Amongst the issues highlighted in those case studies are the curriculum, programming, creativity, student enjoyment and real-life relevance. Our study, which encountered many of the same themes in teachers’ comments, complements and expands on this work by seeking many teachers’ suggestions on the general question of student interest and enthusiasm.

3. METHODOLOGY
As part of the evaluation of our initiative – cs4fn, a magazine for students about computer science – we enclosed a questionnaire with a copy of the magazine [3] and sent them to the head of ICT at 2,629 secondary schools and sixth form colleges (institutions for post-16 education) throughout the UK. 134 completed questionnaires were returned (a response rate of 5.1%).

In addition to questions about their views and perceptions of the magazine’s quality and usefulness we asked them for their responses to a more general question: “The government believes that computing is important for the UK, and many people at universities are trying lots of different ways to get students interested in computer science. cs4fn is just one example. How would you do it?” The research presented in this paper is based on an analysis of the replies from the 115 ICT teachers (60.2% male) who answered this question.

Using standard qualitative analysis techniques, three of the authors analysed each response to find and code themes that emerged from teachers’ comments [7, 20]. We used an iterative process, repeating our coding until no new concepts emerged. Each author worked separately to code the responses and develop an individual set of broader themes. We then met to compare these and agree on the final grouping of themed concepts. We used card sorting to do this: each code from the three analysts was written on a card and these were sorted into logical groupings, also removing duplicates. This was done iteratively until a consensus emerged. Despite the researchers’ having differing degrees of familiarity with computer science and teaching issues, each of them (coding separately and without sharing information) had noted the same recurring concepts. This made it easy to agree on broader themes and indicates that the themes we identified emerge strongly from the text, increasing confidence in the results.

A set of six major themes was identified. These were then used (by two of the original three authors) as the codes with which to recategorise the full list of responses. Although this round of coding was also completed separately, there was strong agreement between the two coders’ classification of the comments, further indicating the strength of our method. The six major themes and teachers’ comments on each are set out below in the results section.

3.1 Limitations of the study
It is important to note that there are potential biases that could have affected the results of the study. The respondents are self-selecting and likely to be keenly engaged. Their ideas and views may not represent those of the wider population of ICT teachers. Consistent answers suggest that the question was similarly understood across respondents. However, its wording may have affected how teachers responded in terms of university involvement. The mention of universities in the question may have steered respondents away from mentioning other university enrichment programmes. On the other hand, it may have primed them to think about universities (especially as the questionnaire came from a university), causing university initiatives to be overrepresented in the results. Further work could resolve this.

4. RESULTS
Within each of the six overarching themes we have highlighted the different strands of thinking that emerged from teachers’ comments, supported with illustrative quotations.

4.1 Values and motivators
One clear theme emerging from the teachers’ comments was a discussion of the sorts of values and motivators that would be present in a solution to the problem of student interest. From their comments, a picture emerges of what teachers think students would like their experience of computing to feel like, and what could motivate them. A 4-point ‘4Rs’ framework of motivators emerges from the data:

1. Recreation
2. Relevance
3. Regard
4. Reward

The strongest current running through the comments is that students would be attracted by a feeling of recreation – in-the-moment enjoyment. Many teachers used words like “fun” and “excitement” (often together) when making their suggestions, “Making computing fun!” was a typical comment. Many suggested specific ways to make computing fun, typically mentioning games (both to play and program), equipment and resources (such as to build robots or design apps) or clips from films or YouTube. There were suggestions of what was not fun –
one teacher said students found writing up work boring. Another suggested that computing needs to be “fun and lively. Not too much coding and syntax to begin with.”

In a further strand of comments, teachers suggested that students would be more interested in computer science if they could recognise its relevance to their lives. For example, one teacher wrote that students find computing “boring” but “the only thing that really works is HTML, as they can apply it to real things”. For some teachers, relevance to real life encourages recognition that computer science is an attractive career path. One wrote “students often don’t see the benefit of the current curriculum – they need to see it applied to everyday lives to encourage them into the IT industry for employment and innovation”.

Teachers also suggested improving what might be called regard – a positive sense of being part of a group that is well-respected. Teachers lamented that computing is seen as “geeky”. Some noted that this image makes it difficult to recruit girls into computing classes. Specific suggestions to improve this image were often media-based: teachers suggested funding films or TV programmes, and one said “get a celebrity to endorse it”. We expand on the issue of the image of computing in the section on society below.

A final current running through the theme of motivators for students was the enjoyment of reward. While the other sources of enjoyment were more immediate, reward makes promises about the future. Some teachers mentioned a sense of accomplishment after making a program, while others wrote about more concrete rewards, such as competition prizes, future profit or interesting careers (as suggested by a desire for students to have contact with business – see below). However, reward did not emerge as strongly as the values mentioned above. It is not clear why. Vahrenhold proposes that computing teaching lacks a reward students can imagine at the end of their toil [25]. A teacher of French can promise a trip to Paris, but what can a computing teacher promise? If teachers do not propose reward very strongly as a motivator for their students, is it because they do not think it works as well as other motivations, or because they cannot think of the equivalent of a trip to Paris? This is a question for future work.

4.2 Extra-curricular engagement

A large number of respondents made suggestions relating to extra-curricular activities such as having computer clubs, guest speakers and school trips to a variety of external events and activities including universities and industry. Almost a third of those highlighted clubs and offered some detailed examples of what types of programming skills (game creation) or software / tools (Lego Mindstorms, Raspberry Pi, Scratch, robotics kits) these might involve.

Many teachers are enthusiastic about welcoming visitors into their schools to give talks but also referred to the need for opportunities to take their class out of school so that they can experience computer science in other work-related or fun settings. Only a few specifically mentioned universities for this purpose and these mentions were more related to general ‘taster days’ with businesses being suggested as a suitable location for a visit, as well as other fun events such as the Gadget Show (a British television show about technology which has an annual live public event), which one frustrated teacher noted was not open to children.

The idea of competitions was also suggested as a fun way to engage students but also as an opportunity for the computing / IT industry to ‘promote a positive image of careers in the industry’ along with talks and media coverage.

4.3 What to teach and when

Of all the themes that emerged from the teachers’ comments, by far the strongest was the curriculum. It was clear that the most desired change to the curriculum was the addition of programming. Some teachers discussed the differences between ‘ICT’ as it is taught in the UK and ‘computer science’, and programming seemed to mark an essential difference for teachers between one and the other. For example, one teacher explained that their school had introduced “elements of computing” in their ICT courses by “gently introducing programming concepts.” They also wrote: “With the greater emphasis on computing we are aligning schemes of work to more formally reflect more programming concepts.” The fact that this teacher mentioned gentleness reflects another aspect of teachers’ comments about what to teach and when. Teachers discussed the idea that the learning curve in computing needs to be managed. “We believe in understanding the basics and building on that” was a typical comment. Another teacher praised Scratch, writing that it has “a low entry level – pupils of all abilities can get something working – but a high ceiling – sophisticated programs can be created. Too many others are too hard or too easy…” Some teachers emphasised the higher end of the learning curve, commenting that students should be able to go on to do higher-level programming in school if they wished.

Only one teacher mentioned computational thinking [10, 27]. This is perhaps surprising given the emphasis placed on it by the academic community. It is not clear why this is not on the radar for teachers in the UK. They may know of it but do not consider it to be an important factor, or perhaps they are not aware of it at all.

Along with comments about what to teach, many teachers discussed when to teach it. “Get them early” was a common sentiment. Many teachers gave UK years seven, eight and nine, when students are between 12 and 14 years old, particular significance. One teacher explained this was because in the following stages students are able to choose courses to follow at GCSE (ages 14-16) and A-Level. However, other teachers suggested starting computing in primary school. Some teachers chose to comment that they felt students ought to be given a choice about how far they take computing. A few commented that computing was not for everybody. These few comments dissented from a general view among our respondents (consistent with a current movement in UK computing education) that programming should be taught to all learners, often from primary school. It is interesting that some teachers chose to answer a question about how to get more students interested in computing by stating, for example, “It has to be an elective and the pupils must be willing to persevere outside of a graphical environment” [emphasis in the original] or, referring to programming, “not suitable for all and about 50% of KS4 [Key Stage 4 – 15-16 year olds] will really struggle with concepts”.

4.4 Support for teachers and teaching

Many respondents highlighted concepts relating to support for teachers. We included in this theme any statements about teacher training, classroom and other student resources.
Several respondents acknowledged the need for strong subject knowledge in CS teachers and felt that this was lacking, or that more support could be offered to otherwise competent teachers to improve their CS knowledge. One commenter said “I would also encourage more CS graduates to train as teachers”.

Many commenters indicated a need for ready-made and well-tested lesson plans and some suggested a central website to collate this, alongside other information and resources. Physical or virtual resources that were suggested included physical computing kits (such as the Raspberry Pi) and access to software (such as Scratch), as well as the ability to keep kits and hardware up to date. Some teachers noted the need for funding to keep resources up to date; others stressed that resources should be free. One teacher noted the problem of school IT infrastructure which can restrict students’, and teachers’, access to the network, making it harder for students to have the freedom to experiment.

Most teachers discussed resources for students already enrolled on particular classes, but one or two teachers also mentioned the need for resources aimed specifically at boosting CS uptake, particularly female-friendly material.

4.5 Wider society

This theme included statements about the groups that need to be engaged with, especially businesses, and ideas about bolstering the image and role of CS in culture.

Echoing the recommendations of the Royal Society [23], several felt the need for better links with and more input from businesses either in terms of the industry taking action to promote CS careers but also in providing school talks and resources. Teachers acknowledged the benefits of two-way visits, having local companies provide speakers to schools but also school visits to the companies’ sites. Few respondents specifically cited universities for engagement. This is interesting given that they too provide extracurricular resources to teachers. This could signal that teachers are unaware or dismissive of the potential for engagement with universities.

A rapid way of potentially shaping or changing attitudes about a topic is through mass media and a number of respondents suggested the need for more mention of CS in television programmes, with one suggesting “programmes on children’s TV / family prime time in a similar format to Bang Goes The Theory [a British television show about science aimed at young people]”. A few also suggested the creation of YouTube videos for this purpose, providing something that can be easily viewed on mobile devices but also as a potential classroom resource.

Teachers wrote about difficulties in recruiting girls to computing and one respondent wondered if the geeky image was in part to blame – “try to encourage more girls into the computing field. The subject is still seen as 'geeky' and for 'anoraks'”. Teachers also wrote about a confusion between ICT and computer science – not just in schools but in society – as well as the need to “convince parents and school management (particularly the latter) of its importance and value as an academic discipline”. Perhaps a dedicated ‘public engagement with computer science’ movement is needed, similar to the broader ‘public engagement with science’ movement.

4.6 Learning through creation and play

Many comments suggested improvements to students’ learning experience in computing. In order to interest more students in computer science, teachers suggested including more interactive, hands-on experiences. They often suggested students would enjoy building or making something themselves, which ties this theme closely with the discussion of including programming in the curriculum. Indeed, most of the suggestions for learning activities centred on software design – game design and mobile app design were very frequent suggestions, often in the same comment, as in this teacher’s example: “Use app design to excite and game design to entice”. Suggestions about physical computing were less frequent but still present: many teachers mentioned Raspberry Pi while others mentioned robotics.

A few teachers suggested learning by play. One teacher wrote “Get them early (primary school!) – lots of technology / robots / apps to play with”. Playing games in class was cited by one teacher as a way of learning computing “without realising”. One teacher distinguished between the respective popularity of making and playing, suggesting students would be attracted by “…activities such as playing games, but not all pupils are interested in programming computer games. It seems to be a bit of a niche market (programs)”.

A thread of discussion on technology, particularly new and impressive technology, was woven throughout the comments on creativity and play. Teachers tended to value software and equipment, and did not mention paper-based activities or low-tech play such as is contained in CS Unplugged [1], for example.

The theme of making and doing is perhaps most significant for its seeming unanimity: very few suggestions about learning experience were not about increasing the creativity or interactivity of computing. It seems clear from teachers’ comments that they generally consider those elements lacking in current students’ experience.

5. DISCUSSION AND FURTHER WORK

If there is one clear idea that emerges from teachers’ answers, it is that they believe programming should be taught in schools. However, programming is taught widely in computing classes in the USA, a country that still struggles with problems of student interest [15, 21]. If and when programming comes to UK schools, it is unlikely to be a panacea. Sentance [24] warns that “describing computing as programming is misleading to students and may not recruit effectively”. Once programming is implemented it is unclear from teachers’ comments what will be the next big idea for engaging students. Teachers will soon have their hands full implementing a new curriculum. There may be a need for others to step in with ideas about the next step for engaging students.

Many teachers suggested introducing extra-curricular computing clubs in schools, but in general their vision of what a club might be like resembled their recommendations for computing classes, with programming playing a very prominent role. Perhaps a good use of computing clubs would be for younger learners – introducing them to topics and experiences they would encounter in a computing class and thus priming them to enroll when they are older. For older students, who are already in computing classes, computing clubs could function like science clubs, providing enrichment and more challenging experiences. Although many teachers suggested forming computer clubs, there is currently not a strong organised movement in the UK to support
them. This is a reverse of the situation for computational thinking, which goes mostly unmentioned by teachers despite strong support in academia.

Academics may need to better sell their own relevance to the discussion: although many teachers mentioned engagement with industry, very few suggested roles for universities to play. It is unclear whether this is because of the context of our questionnaire. It may have inadvertently deterred respondents from suggesting engagement with universities. It is also possible that teachers are unaware of the role academics could play (and desire to play) in shaping school computing. Further work is needed to determine which is the case.

We would also like to further explore the 4-point framework identified in the ‘values and motivators’ section: for example looking at whether the values identified are observed in other discussions about computing, or successful ‘excite’ initiatives. Further work could compare the framework with other school subjects. For example, ‘in-the-moment’ recreational enjoyment is valued highly by the computing teachers in our study. How does that compare with teachers of other school subjects? Do, for example, teachers of French or physics value other aspects more highly? The way they envisage student experience of their subject may be instructive for computing.

6. CONCLUSIONS AND FUTURE RECOMMENDATIONS

In this paper we analysed 115 free-text responses from British ICT teachers, answering a question on how to interest more students in computing. A number of themes emerged from that data that suggest recommendations for organisations wishing to address the problem by engaging with teachers, who must be part of any school-based solution.

Whilst the main themes emerging from the study broadly map to the prominent campaign issues in UK computing education, such as the need to challenge stereotypes, the importance of curriculum change and introducing programming, there were some notable areas that were barely visible in the data. In particular there was little mention of teaching based on computational thinking principles or the ‘unplugged’ approach to teaching deep computing principles in a low-tech way. Teachers seemed to cast their discussions of ‘fun’ in terms of making lessons themselves appealing, rather than bringing out the intrinsic appeal of deep principles of computing. If academics wish computational thinking principles to be more prominent in UK schools, our research suggests that they need to engage more fully with teachers than they are at the moment.

It may also help for academics to align their campaign for deep principles to the priorities and values teachers give in their comments. For example, in their comments, teachers valued a learning experience that included large amounts of making and playing, which may be a reason that programming and physical computing were also valued so highly. Advocates of teaching deep CS principles could find topics that demonstrate the diversity of the subject and can be taught with creation and experimentation at their heart. Interaction design, for example, fits this description. It involves some core computer science concepts, like Fitt’s Law, the importance of recognition versus recall, and the importance of recognising human error. It could also fit teachers’ valuing of real-life relevance by being linked to product design and careers.

A number of teachers mentioned a desire for a repository of high-quality resources and lesson plans for teaching computing. Computing At School [8] have taken up this task. That is a welcome development, and our research suggests that as long as it is well publicised, it will meet with an enthusiastic reception. Again, if the materials are cast in the same terms as teachers expressed in our survey, this may speed their acceptance. One more resource that could benefit from good publicity may be universities themselves. Teachers seemed much more apt to call on industry for demonstrations and guest speakers than universities. This is a shame, as computer science departments are arguably more widely spread through the UK than innovative computing companies. Universities may also be more willing to give up time to help with education. On the other hand, academics may find it productive to engage with business (teachers’ natural point of call) to provide better teacher support. UK universities are being encouraged to form links with business – engagement on this issue could allow them to form such links in the service of the public. A network of support for computing clubs may be a popular way to do it.

The current overhaul of computing in UK schools is a huge opportunity to halt the decline of student interest. It depends on the support of teachers, as does any effort to excite school students. By listening to teachers’ voices it will be possible not only to support them in giving students a more interesting vision of computing, but also to help build a classroom experience that encompasses the breadth of the subject.

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8. REFERENCES


