Embedding Technology in the Classroom: the Train the Teacher Model

Judy Robertson
School of MACS
Heriot-Watt University
Edinburgh, UK
judy.robertson@hw.ac.uk

Andrew Macvean
School of MACS
Heriot-Watt University
Edinburgh, UK
apm8@hw.ac.uk

Katy Howland
School of Informatics
University of Sussex
Brighton, UK
k.l.howland@sussex.ac.uk

ABSTRACT
This paper focuses on the importance of evaluating educational technology for young people aged 10-18 in naturalistic classroom contexts. We present the Train the Teacher Model (TTM) which formalizes a model for IDC researchers to use when deploying and validating an educational system. Our key findings indicate the need to work in partnership with classroom teachers, providing both initial training and continued support. This will both result in more valuable research data, and address a gap in teachers' continued professional development. The TTM aims to ensure that teachers, students and researchers can benefit from innovative educational systems deployed in real classroom contexts.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation] User Interfaces – *Training, help and documentation*; K.3.0 [Computers and Education] General;

General Terms
Human Factors, Theory

Keywords
Teacher Training, Educational Software, Ecological Validity

1. INTRODUCTION
A special theme of Interaction Design and Children 2012 is on pedagogy, reflecting the importance of designing technology which is appropriate to the needs of learners and teachers. In this paper we argue that comprehensive longitudinal educational evaluation of new technology should be carried out within naturalistic classroom settings. We propose a model – Train the Teacher – which researchers can use to increase the ecological validity of their educational systems, while ensuring that teachers and students benefit through technological innovation in their classrooms.

In a recent analysis of the values of IDC researchers, Yarosh and colleagues noted a "strong emphasis" on technology to support learning (p138) [32]. They report that 13% of IDC conference papers published since the conference began in 2002 were focused on learning, and that 42% of these emphasized the importance of integrating technology with the curriculum [32].

Considerable advances have been made in learner centred design methodologies for design and evaluation of technology products (see [16] for a summary). Thus far, the focus has been primarily on including the learner during the design process, while less emphasis has been placed on the role of the teacher. It is acknowledged that the teacher has an important contribution to make to the design of educational technology in identifying the pedagogical requirements from a practical perspective [16]. Beyond the initial design process, the potential contribution of teachers is arguably even greater. Teachers are the gatekeepers to effective integration of technology in day to day learning; the success of innovative educational technology in the long run will be determined by the extent to which teachers embrace it in their practice.

To study technology usage in schools it is desirable to have access to a typical classroom set up with the teacher planning work and leading lessons, allowing them to incorporate their own knowledge and experience. Researchers should ideally have access to a number of schools with this set up to gain an understanding of how a tool would function in a real world classroom scenario.

However in order to achieve this, more emphasis must be placed on the teacher's role in the process of embedding new technology in classrooms, in particular the attitude and level of training the teacher has received [5]. Guzman and Nussbaum highlight that "teacher training must be at the heart of any attempt to formally incorporate technological tools into classroom activity" (p.454) [17].

Previous research has identified weaknesses in the current provision for training teachers to use new technology [10,12, 22, 23]. The implications of this are two fold; first, teachers cannot fully utilize the technology within their classroom, to the benefit of themselves and their students. Secondly, researchers investigating the uses of educational software cannot receive the ecologically valid results required to fully understand technology in the classroom. Researchers are thus faced with the problem of how best to approach training teachers when embedding new technology in their classroom.

Practitioners have begun investigating these issues within computing education at secondary level [9,12]. However, while this work identifies the importance of the teacher's role, there exists no formal methodology for how best to approach teacher training from both the teachers' and researchers' perspective.

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This paper addresses this problem by proposing a model for training teachers around the use of innovative software in upper primary and secondary schools: *Train the Teacher Model* or *TTM*. This model is intended to be one that:

1. Enables researchers to conduct higher quality evaluations through embedding of their system in realistic classroom settings.
2. Trains the teacher for full use of the system, while respecting pedagogical practice and academic freedom

The rest of this paper is organized as follows. First, we provide greater detail on the importance of ecological validity and realism within HCI. Following this, we outline the importance of teacher training when attempting to reach these goals, along with the current concerns highlighting how current approaches fail to adequately prepare both teacher and researcher. We then present the TTM, our approach to addressing these problems, along with a case study example outlining the success of the model and illustrating our choices. We conclude by describing how the TTM can be used by researchers to ensure the success of a technology enhanced learning research project, as well as the current limitations and room for extension within the model.

2. BACKGROUND

2.1 Evaluating educational technology in schools: the issue of realism

It is worth considering *why* researchers should be motivated to embed new technology in the classroom. There are two answers to this. Firstly, in doing so, they are ensuring that their research has a positive impact on society, which is particularly appropriate for technology innovation stemming from tax-payer funded research. Secondly it leads to higher quality research with greater external validity and representativeness.

From the perspective of producing higher quality research, embedding educational technology in a classroom enables researchers to evaluate the educational effectiveness of the technology in the most natural context possible. Jensen, Skov and Vej [21] note that "our discipline [IDC] has a strong focus on natural setting environments. This is pursued primarily through different kinds of field studies and secondarily through action research and case studies"(p.83). However, Yarosch and colleagues' more recent analysis found a lack of longitudinal evaluations within IDC. They recommend that IDC researchers conduct more long term evaluations, warning: "The difficulty of deploying and evaluating a system over a longer period of time cannot be underestimated, however neither can the importance of doing so."(p143) [32].For this reason, a model which considers how longitudinal evaluations can be conducted in naturalistic settings would be of use to researchers.

The issue of evaluating technology in realistic settings has also been recently discussed in the wider field of HCI. Lew et al. [24] raise awareness of the importance of realism in HCI research, noting that the external validity of an experimental design can be reduced by lack of realism in: the appearance of an experimental interface, the content of the interface, the activity users are asked to perform, and the setting in which the experiment takes place. They write that "To document an effect with a field experiment serves as a powerful indicator of the effect's real-world significance, suggesting that the effect is still noticeable in light of the noise and externalities associated with the real-world."(p.423) [24]. Similarly, Carter et al. discuss the problem of ecological validity in the context of ubiquitous computing, noting that "for a field to mature, designers and researchers must be able to close the iterative design loop, encompassing both prototyping and evaluation, and learn from their prototypes." (p.49) [6].

As with many domains, conducting ecologically valid evaluation can be problematic for educational technologists due to a number of pragmatic and institutional issues. It can be hard to gain access to schools, and there are often challenges to address, such as fitting in with the prescribed curriculum and timetabling constraints. In many cases researchers do not attempt to carry out studies within schools; community based clubs are a popular alternative setting for evaluative studies of educational tools [9, 20, 27]. These have the benefit of allowing contact with children of the right age range, and giving the researcher the freedom to structure activities to fit with their data gathering requirements. However, the correspondence to a real classroom context tends to be poor. The freedom of the setting can be a disadvantage because it doesn't reflect a real classroom environment, and the participants are likely to be self-selecting and therefore reasonably well motivated.

Another approach adopted is working within schools, but taking a small group of pupils out of regular lessons to use the tools, or running experiments in after school clubs [19].This can get closer to the classroom context, but the smaller numbers involved and the novelty of working outside the classroom with adults who are not the regular teacher are likely to have an effect. Also, after school clubs typically do not teach or assess according to a formal curriculum.

Where researchers do surmount the practical difficulties and gain access to a real classroom full of real pupils they are rewarded with valuable data on how the technology in question functions in a naturalistic school setting. However, there are still a number of factors that can detract from the authenticity of the scenario. One key issue can be the identity of the person(s) introducing the tool and helping pupils learn to use it effectively. Unless a teacher receives extensive training with the technology they are unlikely to be confident enough to run the classes without significant support from researchers, either as additional classroom helpers available to answer questions or as 'guest teachers' who run demonstration sessions. Despite their best efforts to avoid bias, some researchers still feel that their presence at evaluative studies is a potential limitation to the work as it may influence the participants' experience [20]. It can also prevent teachers from taking ownership of the technology and making the best use of it based on their expertise and experience.

A further factor can be restrictions on the time allocated for use of the tool. For some types of heavily controlled experiment it may be desirable to limit the usage to a specific period, but where the aim is to evaluate in a naturalistic setting it is important to allow more open ended usage of the technology.

Finally, where researchers are required to spend considerable periods of time within a school, introducing and evaluating a tool, they are very limited in the number of schools they can consider in their research. Collecting data from more schools could ensure that the data is more likely to be representative of the school population in general.

The proposed methodology within this paper enables researchers to transfer the technology they have developed into schools in a realistic way by empowering a number of classroom teachers to use the technology in their everyday practice. The researchers benefit from the naturalistic data collected, and from the insights of experienced teachers. The teachers benefit from continuing professional development as well as new skills and confidence around technology. As a result, the learner – who should be at the heart of all educational technology development – gains from using innovative yet appropriately designed technology with the support of an experienced teaching professional.

2.2 Current approaches to training teachers in technology use

There is evidence that adequate teacher training is essential for the successful use and evaluation of educational technology [17, 35]. However, while practitioners have realized the importance of teacher training, studies have shown that the current approaches appear inadequate. Conlon described a UK national initiative to train all teachers in ICT skills as a "shocking" failure [10]. Smith and Robinson found that teacher training for the use of technology based solutions is weak and does not properly encapsulate the relationship between technology and schools [31]. Lawson and Comber and Lawless and Pellegrino all found that most of the training of educational systems has focused on the operation of technology, rather than how it could be used in the classroom as an effective educational tool [22, 23]. This problem is summarized by Ertmer and Ottenbreit-Leftwich when they explain "It is time to shift our mindsets away from the notion that technology provides a supplemental teaching tool and assume, as with other professions, that technology is essential to successful performance outcomes (i.e., student learning). To put it simply, effective teaching requires effective technology use." (p.256) [15]. Harris outlined the need for new approaches that "genuinely respect pedagogical plurity and honor teachers' academic freedom" (p.121) [18]. The implication from a teaching perspective is that many teachers feel underprepared or lack confidence when it comes to using technology in the classroom [1, 14, 30].

With this in mind, what attempts have been made at better understanding the problems, and how, as researchers, can we help embed technology in the classroom? Practitioners across various domains have begun looking at the problem, in an attempt to better understand what influences effective technology use. Sang et al. found in a study of 820 teachers in China, that the use of ICT technology in schools could be directly correlated with the level of assistance and support received by the teacher [30].Chen et al. identify the need for teacher support (from both researchers and other teachers) as an important factor in developing the teacher's competency in successfully using technology in the classroom [8]. Additionally, Zelin and Baird found that having enough free time after training sessions was important to practice what the teachers had learnt [33].

Within the HCI and IDC communities, there exist only a few examples of work which directly considers the role of the primary or secondary school teacher, their training and continued support, during the execution phase of a project. Robertson and Howells outline the implications found from their study of a game design project. Among these, they stress the need to both train and support the teacher, and identify the need for "courage" in the attitude of the teacher when embedding new ideas and technologies [28]. Cordova et al. identified the importance of teacher training when running a non-residential camp for high school students using the ALICE software system. The authors outline a model for successful camps which utilise teacher involvement as a key objective [12]. While trying to foster an interest in implementing Scratch into a school curriculum, Clark et al. saw the success of running teacher workshops to encourage educators to use the software within their school. They found that through the training, teachers' attitudes towards computer science were positively influenced by their experience [9]. The process of supporting teachers throughout the execution of software in a preschool context was outlined by Barbuto et al. Through careful training and support, the authors note, "training led to positive attitudes, greater technology expertise, and skill in scaffolding children's computer use among teachers" [3].

2.3 Summary of requirements for technology related teacher training

The lack of success in previous attempts at teacher training around technology skills demonstrates that promoting lasting educational and technological change in the classroom environment is extremely challenging.

However, building upon the previous section, there exists a small body of work which aims to formalize the findings of evaluations of training teachers in the use of educational technology. In this section, we outline these in an attempt to begin creating a formalized model for teacher training within the context of innovative educational technology.

2.3.1 The Key Requirements

From the literature, we can abstract the following list of key requirements

1. Provide examples of other teachers' successes, emphasizing student outcomes [15].
2. Support and encourage risk taking and experimentation [15].
3. Lead with strong leadership to ensure high morale, sufficient resources and support [24].
4. Ensure teachers understand how to use both the technology itself, as well as understanding the technical constraints and other contextual factors required to enable the project, and have confidence in what they are using [34, 35].
5. Give teachers enough free time after training sessions in order to let ideas properly set in [24].
6. Identify the specific curricular goals which can be supported through the technology [7, 35].
7. Specify how the technology will be used to help students meet and demonstrate those goals [7].
8. Involve teachers in the decision making process, to ensure the technology integration is meaningful to them [24].
9. Help develop a plan with realistic goals and a feasible implementation outline [24].
10. Provide support to teachers to remove roadblocks and restraining factors [8, 24, 31].
11. Help build and support a community from which teachers can learn from and support their peers [17, 24].

3. THE TRAIN THE TEACHER MODEL (TTM)

Based on the requirements gathered from the literature review, data collection considerations and the experience of one of the authors as a teacher and teacher educator, we developed the TTM, presented below.

The TTM is intended for use by researchers who wish to conduct naturalistic evaluations of innovative technology in upper primary or secondary school settings (for learners aged 10 -18). It offers guidance on how to plan a sustainable project in which multiple schools embed the technology in their everyday classroom practice initially over a period of months, but with the aim that the schools will continue to use the technology with minimal researcher support over a number of years. It is assumed that the technology is in a relatively mature state, that the software contains logging capabilities and that at least one pilot study has been conducted during which the researchers have identified potential classroom management issues and gathered examples of good practice to disseminate.

A running example from the *Making Games in Schools* (*MGiS*) project is given as an illustration. During the MGiS project, the authors trained teachers to use game making software called Adventure Author in their classrooms with learners aged between twelve and fourteen. The project was funded by EPSRC for 18 months via the Partnerships for Public Engagement programme which aims to make research knowledge accessible to the general public. In terms of the human resources involved, the project employed one educational researcher (50% Full time Equivalent - FTE), an academic member of staff 5 hours per weeks as principal investigator, a student to provide technical support on a casual basis, and the advice of a professional science communicator as project mentor for 3 visits during the project. Schools were not funded to take part in the project, however the teachers received free residential training and ongoing support from the research team. A major goal of MGiS was to make the use of Adventure Author in schools sustainable; our aim was that at the end of the funding period the software would be used in twenty or more schools without the intervention of researchers, but that we would continue to collect research data in the form of online surveys.

3.1 Teacher recruitment and initial training

3.1.1 Recruiting teachers

The first step in TTM is to advertise the innovative software and training opportunities to potentially interested teachers. It makes sense to begin with teachers who work at local schools, although the convenience of a geographical location may be outweighed by other factors such as the available IT support, or the enthusiasm of the staff. The teacher who took part in pilot work with the software can be a useful ambassador for convincing colleagues that the project has merit. A particularly compelling way to persuade teachers of the educational benefit of software is to enable them to see learners using it, perhaps in a visit to the pilot classroom, or in a video. Presentations from researchers at teachers' conferences can also be a useful way of attracting teachers to consider the use of the new technology. This is consistent with requirement 1 which suggests providing examples of other teachers' successes, emphasizing student outcomes.

A key factor in successfully embedding innovative software in multiple schools is the commitment of the teachers. As the research team will be investing their time in training teachers, it is wise to make sure that the teachers who sign up are committed, enthusiastic and willing to undertake potentially risky projects albeit in a supportive environment (see requirement 2). They should understand that it is likely to require them to put in additional effort over and above their normal workload to get a project up and running. We therefore advise requiring teachers who want to take part in the training to submit an application form outlining why they want to be involved, what benefits they feel it will bring for their learners and how they would plan to run the project. Teachers who have taken the time to write an application and who have considered how the project might unfold within their classroom are more likely to be aware of the commitment they are making.

However, teacher commitment by itself is not enough; the teacher must have the support and permission of the senior management in the school. Without this, the project may end abruptly if the head teacher does not perceive the aims of the school and the project to be compatible, or gradually fade away if the head teacher does not allow time within the teacher's other responsibilities to take part in the project.

Lastly, even the most committed teacher with the full support of the school management cannot make a project succeed if the necessary IT infrastructure is not available. School technology infrastructure is highly variable and is often out of date, particularly in state funded schools. Research software is often resource intensive, requiring relatively high spec hardware which may be unavailable in classrooms. This situation is unlikely to change; cutting edge research software will always be several years ahead of mainstream school hardware. It is therefore important to be selective about which schools can take part in the project on the basis of the hardware to which they have access. To avoid wasting resources and disappointing eager teachers and learners, it is important to establish whether the software will run on the school system before investing time in teacher training. It is worth ensuring that the school technician has successfully installed and tested the application rather than simply checking whether the hardware meets the theoretical technical specification.

3.1.1.1 Recruitment in the Making Games in Schools project

At the start of MGiS one of our main concerns was whether we would be able to attract enough teachers who worked in schools with the necessary hardware available. Although the graphics and hard disc requirements of the game engine seemed modest, the hardware in some of the surrounding local authorities could not meet them. However, we gave presentations to a local group of Computing teachers who were also invited to a school where a pilot took place the previous year. We had also previously presented at regional and national teacher conferences and so had a 'waiting list' of potentially interested teachers. We worked in partnership with the national body for curriculum development to advertise the project on email lists and the national virtual learning environment for teachers.

This resulted in a steady stream of applications such that we were able to fill all the places we could fund. Participants were selected after filling in an application form which stated how applicants would use the training for the benefit for their classes. They applied with a colleague to maximize the chances of the project succeeding because they could motivate each other during difficult patches.

3.1.2 Initial training

An important principal behind the model is that of valuing and respecting teachers. This is likely to engender a sense of ownership, commitment and engagement which is necessary to the success of the project. A consequence of investing in the teachers is that they will be more inclined to contribute to the project in terms of training other teachers and "evangelizing" among policy makers.

Just as the researchers should respect the teachers, the teachers must be convinced that the researchers are credible authorities not just on technology, but also on pedagogy and classroom management issues. If the teachers believe that the researchers are ignoring practical classroom issues, or are naïve about them, they will be less inclined to try the software. For this reason, it is important to have mixed expertise in the team delivering the training, such as a domain expert working in partnership with a teacher educator with experience in educational leadership.

Requirement 3 notes the importance of strong leadership for morale, sufficient resources and support. TTM suggests this can be accomplished in two ways. The research team should act as educational leaders by innovating with a pedagogically sound approach. They should also encourage the teachers to lead educational innovation in their own schools by introducing new classroom practice around technology and by training their colleagues.

When preparing the training sessions, we recommend that the research team should include the activities of: instruction on software usage; extensive hands-on opportunities with software; modeling of appropriate pedagogic approaches; discussion of theory; mapping of the learning outcomes to the curriculum; reflection and class planning. As this is a lot of material to cover in any depth, we recommend that the courses be for substantial periods of time, either as an intensive training course over a period of days, or as a series of regular classes.

Requirement 4 specifies that teachers should understand and have confidence in the use of technology, and requirement 5 emphasizes the importance of giving the teachers time to practice. A large proportion of the training time should therefore be devoted to teachers using the software for themselves, working on the sorts of tasks their learners would with the support of the research team. This has the added advantage that it puts teachers back in the position of being learners which can give them additional insight and empathy in their learners' experiences when they return to classroom. Time to explore and experiment with the new software also encourages creative risk taking (see requirement 2).

Accessible material which places the technology in the context of the underlying pedagogical theory is required in order to help the teachers make informed choices about how best to integrate the software with their existing teaching approaches, or whether they should consider new approaches. It is also helpful if the research team have mapped the curriculum outcomes to the activities around the technology (see requirements 6 and 7) because teachers are often under pressure to teach within a curriculum framework and will appreciate support in justifying new and potentially risky approaches to their managers.

Reflection is an important component of continuing professional development, and time to consider the implications of the training on teaching practice should be built into the sessions. It should also be encouraged when the teacher is back in the classroom and attempting to evaluate the effectiveness of the project as it develops.

Requirements 8 and 9 note that teachers need assistance in making decisions about how best to incorporate technology within their classes and how to put this in practice within a feasible plan. The teacher educator on the research team has a very important role to play here in ensuring that the training is likely to be put in practice in the classroom through the setting of achievable goals. Empowering teachers to plan their own classes around the technology respects their academic freedom and professional judgment, thus increasing the chance that they will be able to embed the project in their everyday practice. This does have implications for the research designs which are appropriate, as not every learner will experience the same treatment. However, there are wide uncontrollable variations in results introduced by using data from multiple schools anyway (such as differences in teaching quality, socio-economic background, hardware). This does not invalidate the data; it simply necessitates the careful recording of the teaching approaches used and the use of appropriate statistical techniques such as multi-level modeling[1].

3.1.2.1 Initial training in the Making Games in Schools project

In MGiS, teachers took part in 2.5 day residential workshops either on the university campus or at a hotel. Laptops were provided for individual use during the course. All expenses were paid by the project. The MGiS project was in the fortunate position of having a 50% FTE researcher on staff, as well as funding for residential training courses and software for schools.

We structured the sessions according to the sequence we wanted the teachers to adopt in their own classes: expert in-put was followed by time to explore, experiment, understand, apply, develop and consolidate, followed by time to reflect and share. The value of the plenary session at the end of each lesson was stressed, as was the time to play and explore as each new aspect of the software was introduced - play and reflection are two aspects of classroom practice which can be squeezed due to pressure of time, and yet they are two phases which are vital to effective learning. We also considered the various roles and responsibilities that teacher and pupil might adopt.

The training covered not only how to use the technology, but also the accompanying pedagogic approaches and background research and theory. We gave research overviews where relevant at each stage - computing, gaming, creativity, teaching, literacy, etc. This was much valued by the teachers and gave extra depth to the related practical sessions. We also provided manageable background reading (hard copy and blog links).

Reflection was an important aspect throughout. Participants periodically reflected on how their experiences as learners might relate to the experiences their learners might face, considering the wider implications for the different types of learners in their classes, and for staff who would come on board at a later stage. Participants were also asked to reflect on how the pedagogy would fit with their existing approaches and consider whether their practice, or that of their colleagues, would change. They were encouraged to continue their reflections on their return to school, sharing their discoveries and developments with other participants via their blog, as well as encouraging their pupils to reflect on their experiences, all of which helped to guide and shape the project as it progressed.

Time was also given during the course to considering the content, planning and execution of the project, in discussion with fellow participants as well as the trainers; at times these sessions were divided according to the teachers' subject expertise, allowing a focus on computing for some and language and cross-curricular approaches for others. An experienced teacher trainer assisted the teachers in planning their lessons with the technology in conjunction with teaching colleagues.

3.2 Data collection

While the requirements identified above are applicable to all scenarios in which teachers are trained to use new technology, TTM is designed specifically with researchers in mind. From the researcher's point of view, data collection is the most important stage of the project because the data is necessary to evaluate the educational effectiveness of the technology. The problems of collecting data in the wild have been acknowledged in other

[1] Some Learning materials about these approaches are here: http://www.bristol.ac.uk/cmm/learning/multilevel-models/

subfields of human-computer interaction. In order to address the problems relating to noise in the data introduced by realism, the authors of [19] recommend the use of a multi-method approach to data collection in which extensive behavioural measurements based on software logging and combined with interview or questionnaire data to uncover users' perceptions of the technology. Within TTM, software log files of learner interactions could be combined with information from assessment tasks built into the software, survey data on learners' attitudes and interview data on teachers' perceptions of educational efficacy. The teachers' professional judgments about their learning are extremely valuable to assist researchers in interpreting patterns emerging from large volumes of log file data, and can give insight into anomalies in the learners' attitude surveys or assessment scores.

A long term data collection strategy is required so that data will continue to accumulate and be delivered to researchers even as their role becomes less prominent. Online tools can be used to get survey data from pupils, reflections from teachers and log files can be automatically uploaded from the software to a central server. This will reduce the amount of data entry and onsite visits required by the researchers in the long run, making analysis more manageable.

Teachers and researchers using TTM can be seen as striking a bargain: the teacher gets free continuing professional development and the means to educate their pupils in an innovative way and in return provides the researcher with valuable data which will enable the researcher to evaluate and ultimately improve their technology and further develop their theories. A problem that can arise is that the teacher, having received the training and support, does not keep up their end of the bargain by returning the requested data. We do not mean to imply ingratitude on the part of teachers, merely that they are under constant time pressure and are in a sense duty bound to maximize the time their learners spend in learning tasks as opposed to completing questionnaires for research purposes. This problem is compounded by the fact that there is often a critical time period for collection of data pertaining to attitudes or learning gains. Some approaches to solving this problem include making the final training session contingent on returning the required data, entering only teachers who return the data into a prize draw for a technology gift to the school and only granting further technology loans to schools who returned data on a project supported by an initial hardware loan.

3.2.1.1 Data collection in the Making Games in Schools project

At the training sessions, teachers were asked to co-operate in data collection in return for the free training and support we gave them. We asked them to get their pupils to complete an online pre-test attitude questionnaire immediately prior to starting the project, as well as a pre-test computational thinking quiz. After the last lesson of the project, they were asked to get their pupils to complete analogous post-test attitude and computational thinking tests. As our software is used on standalone computers, our log files could not be uploaded automatically, so a student visited schools to manually collect the log files. The educational researcher from the team visited the schools towards the end of the first run of the project to interview teachers and pupils about their experiences on the project and observe lessons. Now that the initial funded period of the project is over, our data collection has reduced to online attitude surveys only to help us address an ongoing research question about game making and how it influences learners' attitudes to computer science.

We had some difficulty with collecting all the data we needed in the Making Games in Schools project. Typically teachers found that their learners were struggling to finish making their games within the allotted time for the project. In this situation, some teachers chose to spend the last class finishing the games rather than instructing the pupils to complete an online questionnaire.

3.3 On-going support

After the initial training, the teachers will require ongoing support. This is particularly useful in the first few classroom sessions when bugs and glitches become apparent. Responsive phone, email and site visits are crucial in trouble shooting problems before the teachers and learners become disappointed and discouraged about the project. This meets requirement 10 about removing roadblocks and limiting factors from teachers' paths.

Teachers may also benefit from a visit from a member of the research team with practical pedagogical experience to help them evaluate and reflect on how their new teaching practices are working. The other teachers involved in the training sessions can also be an important source of ongoing support, as specified in requirement 11 which emphasizes the importance of a learning community. An online discussion group, wiki or blog ring can enable the teachers to document and share their own practice, encourage their peers and ask and answer practical questions. This also meets requirement 2 relating to providing examples of teachers' success: good student work and teaching practice can be celebrated online in the teachers' community.

The ongoing cost of providing classroom support can be addressed relatively inexpensively by training undergraduate and postgraduate students to be classroom assistants who can provide technical help. This approach has the added benefits that it trains young researchers in the communication skills necessary for public engagement, and brings school learners into contact with university level role models. Some students may be willing to volunteer to take part in order to learn these skills, or it may be possible for them to do it for credit in their courses.

3.3.1.1 On-going support in the Making Games in Schools project

Once the face to face training was finished, the MGiS teachers returned to their classes to implement their plans, armed with their course handbook full of walk-throughs and explanations reinforcing the practical experiences of the course. They were offered ongoing support in the form of a visit from the experienced teacher trainer and ongoing technical support from a computer science graduate student both in person and remotely by phone or e-mail. Teachers offered each other support and advice through reflective blogs documenting their experiences. Support was also available in the form of tutorial videos and other material to download from the project blog. Teachers also met to share their experiences after their first run of the project.

3.4 Growing the project

An aim of TTM is sustainability: the researcher should initially support the teachers' development but should be aiming to reduce this support gradually until the point where the teacher can not only run the project on her own, but can also train other colleagues to take part, thus spreading the innovation more widely. Once a project had been piloted, the teachers can be asked to share their knowledge with a colleague either at school, at a school in the same cluster or more widely. This can be achieved by the teachers asking colleagues from neighbouring schools to visit in order to observe a class in action, or by teachers giving presentations at conferences (see requirement 2 about providing examples of other teachers' success).

If appropriate, teachers should be encouraged to keep running their projects year on year to build on their successes. While the aim is to reduce the amount of researcher time to the project after the training and initial support period, it can be beneficial for the research team to host and facilitate regular 'top-up' meetings between teachers to maintain enthusiasm and share best practice (see requirement 10 relating to community building among teachers).

3.4.1.1 Growing the Making Games in Schools project

Once a project had been piloted, the teachers were asked to share their knowledge with a colleague either at school, at a school in the same cluster or more widely. The researchers assisted teachers who wanted to present their work at conference by lending them copies of the software and giving technical support.

4. EVALUATION OF TTM IN THE MAKING GAMES IN SCHOOLS PROJECT

An evaluation of TTM in the context of the MGiS project is presented here as an indication to other researchers of the strengths and weaknesses of the approach. Our intention is not to present an empirical evaluation of the Adventure Author software used in the MGiS project, but to consider the effectiveness of the teacher training approach in this case study with respect to gathering ecological research data and championing educational/technological change.

We evaluate TTM according to the criteria of project completion, response rates for data collection, sustainability and participant evaluation. Where possible we put our findings in context of previous educational technology studies although as noted above, there is a lack of similar longitudinal studies within our field to act as a baseline for comparison.

4.1 Training and project completion

In MGiS we trained 31 teachers from 19 organisations in a series of four 2.5 day residential workshops to use the Adventure Author game making software. Of these, five were primary schools working with 11 year old learners, one was a secure facility for educating young people with special behavior needs, one was a support unit working to support young people with special education needs, and the rest were secondary school working with 12-14 year old learners. One primary school and the secure facility (12% of the teachers) dropped out after training but before starting a project. Several schools were delayed in starting their projects due to technical problems installing the software on the school computers, but they did eventually successfully complete a project. We loaned suites of laptops to three of the schools to enable them to run the project once it became clear that their school computers were not suitable.

Our drop-out rate of 12% of the teachers compares favourably to a UK national ICT training scheme for teachers which had a 21% drop-out rate [10], although we acknowledge that as our participants were self selecting, they were more likely to persist than teachers undergoing mandatory training.

4.1.1 Participation rates

By the start of November 2010, when the project officially finished, 13 of the schools had completed exit surveys which indicated how many pupils took part in the project and how long each project ran. A total of 992 pupils took part in this initial 18 month period, for a total of 15772 documented hours of learning with the software. The patterns of activity in the project varied between schools. The mean number of pupils taking part in each school was 70, for a mean of 2 hours per week for a mean of 9 weeks. To illustrate the range of projects arrangements: one school adopted Adventure Author as an interdisciplinary project across 8 academic departments and used the software with all of the first and second year cohorts (308 pupils) for 3 x1 hour slots for 6 weeks. In contrast, a team of literacy advisors working with pupils with special educational needs worked with 15 pupils for 2 hours a week for 8 weeks.

To put these figures in a financial or resource context, suppose a researcher had visited each of the 13 schools for two hours per week for 9 weeks (the average). This would have taken 234 hours of contact time, plus travel within the 50 mile radius of our university, plus the administrative overhead of organizing each visit. In contrast, in MGiS, we spent around total 66 person hours in contact time: 40 person hours running the training courses plus generally one researcher visit to each school (2 hours of contact time). In four cases we also provided more regular technical support via postgraduate students, but this cost is small. Roughly speaking, by using the TTM model we managed to reach the same number of participants but using only 28% of the researcher cost and the added advantage of sustainability.

4.2 Data collection

In terms of data collection, 744 children completed the pre-test survey and 225 completed the post-test survey (from only 7 of the original 13 schools. This represents a 75% return rate (per learner) on the pre-test and a 23% return rate on the post-test. Log file data was also accidently lost by two schools. The very low return rate on the post-test is obviously problematic but how does it compare to survey return rates in previous research? Baruch et al's meta-analysis found that surveys within the educational sector had a 57% return rate, with a standard deviation of 16 [3]. These rates are typically lower for online surveys (as used in MGiS) – Cohen et al. note that email response rates can be 20% or lower [10].For surveys relating to teacher training, a previous study reported a response rate of 33% [2]. Considered at a school level, our response rate on the post-test was 53%, whereas the response rate of English schools in the important international PISA educational achievement study was 64% in 2003.

In summary, in terms of attitudinal data, the per pupil response rates in the post-test were low (although the per school response rates are healthier) but these figures are not unexpected given documented poor response rates from survey data. The access to log file data was very beneficial, as it enabled us to study patterns of learner behavior in depth and volume.

4.3 Sustainability

After the end of the funding period, all but two schools decided to run the project again with new cohorts of students, generally with more pupils involved. In one of the schools, which will not continue, the teacher moved to a different school where she then started the project with her new pupils. In the other, the school upgraded their operating system and so the software did not operate sufficiently well to continue. Seven additional teachers who did not take part in the training offered by the researchers were coached by colleagues to run the project in their classrooms. Additionally, in one particular school, the lead teacher worked very hard to integrate the project right across the curriculum, thus involving 18 other staff members in art, music, drama, home economics and business studies. From the perspective of disseminating the project to a wider audience, six teachers gave presentations about their work to other professionals outside of their schools, two at a national conference.

Two schools which were not involved in MGiS during the funding period have now successfully completed a project, having become interested in participation after visiting a neighboring school to observe a class in action.

Thirteen schools ran projects in the year after the funding ended. Assuming the average figures from the first year from which we have data (2 hours per week for 9 weeks), this is equivalent to a further 234 hours of contact time which stemmed from the original 66 hours of training, without taking into account the 9 additional teachers who were not trained but who took part due to encouragement from colleagues. Thus, the TTM model has continued to bring benefits beyond the initial funding, and is likely to continue to do so.

4.4 Evaluations from participants

The teachers were very positive about the residential training in their post-workshop evaluation forms. They appreciated the pedagogical discussions as much as the technological training as illustrated in this representative comment "I especially liked the way that the course was embedded in the broader context of professional development, learning theory etc., but without detracting from the core tasks of understanding how to use the software in the classroom." They also valued the classroom ongoing support e.g. "Excellent on-line support and supportive visits." In post project interviews, the teachers reflected on how their pedagogical approaches has changed during the project. They reported that they enjoyed the chance to try new approaches such as pupil-exploration, pupils finding and sharing answers and greater use of group work. Some teachers less-used to using technology in their lessons gained in confidence and enjoyed moving away from traditional paper-based approaches, and others gained the confidence to take a less teacher-led approach to their lessons, having seen how successful it can be to let children work out the software for themselves. Other teachers commented that they enjoyed the opportunity to be learners once again, learning from the pupils as well as their colleagues. One teacher added an interesting additional perspective on this: "And the children enjoyed seeing me as a learner, too!"

The purpose of this paper is not to evaluate the impact of the project on pupils' learning or attitudes in any detail. To summarise – in order to indicate the effectiveness of the teacher training – survey data from the pupils and the teachers' opinions about the pupils' engagement indicates that the pupils were highly motivated across the ability spectrum. For example, one teacher was pleased with "how [the pupils] took ownership of their game and took pride in developing it and sharing it with others." Another wrote the software had "created a buzz in the school". The teachers also noticed an increase in attainment across a wide range of skills including literacy, logical thinking, collaboration and problems solving.

Finally, the MGiS mentor (an experienced science communicator appointed by the funder to advise on the project) offered the following evaluation. "Teachers are overloaded, they will take on new resources only if 1) they are mandatory or 2) they understand they offer real value and are worth them investing time and energy to integrate them into their teaching practice. The MGiS training gave the teachers' time to engage with the project, they had a personal experience of the power of Adventure Author to engage and excite. They could see the rich learning environment it provided and the potential to add to it. The presence of a support system gave them the confidence that they would not be left floundering with IT issues – probably a major disincentive for most teachers." He also commented that the training made the teachers feel valued, which was an important intention behind the model.

4.5 Summary

MGiS which implemented the TTM was successful in terms of recruiting, training, and supporting teachers to embed innovative software in the classroom. As with any project, we have encountered difficulties along the way, not least with collecting data. The volume of data we have collected has been sufficient for our purposes, but the low survey data return rate (per learner) has been frustrating (if not entirely unexpected). There was a high successful completion rate, with teachers reflecting positively on changes to their teaching practice as well as benefits to learners' motivation and attainment. In terms of resources, the model enabled us to reach the same number of learners we could have reached with more traditional researcher visits but with 28% of the cost. As far as it is possible to judge ten months after the official end of the funding, the seeds appear to have been sown for sustainability as evidenced by the fact that the majority of the schools are continuing the project with new cohorts and that new teachers have been trained without the intervention of the researchers. This represents a considerable return on investment for our funders (ultimately the UK tax-payer).

5. CONCLUSION

In this paper we have argued educational technology innovation requires longitudinal evaluation in naturalistic classroom settings. We suggest that key to achieving this is appropriate and effective teacher training. Understanding how best to approach teacher training remains a challenge for researchers working in this application area. While practitioners have begun to approach the problem, there exists no formal model for researchers to adopt when trying to embed technology in the classroom. *TTM* aims to guide researchers who wish to embed their work within a classroom in a sustainable, valid, and effective manner, to the benefit of themselves and their end users. By examining the available literature on teacher training practices we have abstracted a list of 11 key requirements and integrated these with data collection objectives in a formalized model of teacher training; the *Train the Teacher Model (TTM)*. We argue that, the use of TTM should result in more effective teacher training and allow more valid research and greater societal impact.

Key benefits of the approach are increased realism, access to a greater number of classrooms, teachers feeling stronger ownership over the technology and greater sustainability for projects. Limitations of the model include potential difficultly in ensuring data returns, and a limit on the type of data that can be collected. After examining the effectiveness of the model in a case study of the Making Games in Schools (MGiS) project, we are confident that the work presented in this paper is a positive step towards a formalized model of teacher training for IDC research in educational contexts.

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