Tablets are coming to a school near you

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Improving mathematics learning is a major educational challenge. It is predicted that schoolchildren across the developed world, will soon have personal Tablet computers with the potential to support learning. The scope for improvement in mathematics learning support is examined from several related viewpoints: previous contributions of Information Technology, including PC labs for mathematics classes; IT innovations children themselves adopt; an analogy between office work and classroom learning; individualised learning environments such as SMILE; and alternative classroom configurations. The potential of personal Tablet computers as a learner's interactive textbook, notebook, test-paper and progression-record and as a teacher's class management tool is outlined

Keywords: Mathematics learning, learning environment, classroom configuration, personal tablet computer, interactive textbook, class management tool.

Introduction

Maths Education has an elephant in the room: by lower secondary half our schoolchildren "can't do maths". But it gets worse- because, after GCSE, most of the half who can do maths won't (Brown 2008).

This paper considers the possibility of improving the mathematics classroom as a learning environment from several viewpoints and relates these to the potential contribution of Tablet computers. These viewpoints are: earlier contributions of information technology (IT) to education; IT innovations that children adopt; an analogy between office work and classroom learning- comparing a paperless office with a paperless classroom; comparing mathematics learning with learning in laboratory subjects such as physics; some pros and cons of an individualised learning environment; alternative classroom configurations; and a Tablet's potential as an individual learner's interactive textbook and notebook and test-paper and progression-record.

Information technology in education

This paper predicts yet another wave of IT innovation is about to wash over our schools (there have been so many- including calculators, graphing calculators, PC labs, programming in Basic or logo, Excel spreadsheets, Interactive White Boards (IWBs), interactive maths learning software such as Geogebra, Integrated Learning Environments) and considers whether this one could make a significant difference to maths learning. IT has permeated education at all levels and the easy victories have used software technology developed outside education- for administration of student records and Internet access to stored knowledge. Technology specifically for education is expensive (because relatively small numbers are sold) and sometimes counter-productive- thus automated testing can dumb-down learning and IWBs can encourage teachers to do presentations rather than teach (and maths is essentially a learn-by-doing subject). Networked PC laboratories (labs) are now common in schools but, because of their cost, they are scarce resources typically with limited timetabled access for each class. Can we say with any confidence that any of these IT innovations have helped improve mathematics learning significantly? So should we be optimistic about the prospects for yet another wave of technological innovation in the mathematics classroom?

Mobile phones now and Tablets soon

The current generation of schoolchildren love their mobile phones. For many they are their most precious possession and the centre of their social lives. Schoolchildren across the developed world have wholeheartedly adopted mobile phone technology and the whole culture of rich inter-person intra-group communication at-a-distance that has been developed on top of this technology- replacing those sparse at-a-distance communication practices: note and letter writing and landline phone calling. It is striking what accomplished electronic communicators and users of “apps” children have become in a rather short time.

Tablet computers, like the iPad, are currently interactive communicator and book-reader toys for adults. But they are an imminent second wave of “must-have” technology for schoolchildren. Their large screens (about 10 inches diagonally) and large memory (16 GBytes minimum) and similar processing power to Netbook PCs differentiate them from mobile phones and give them a different IT dimension: they are not just communicators, they are computers- with all that fact implies.

iPad the market leading Tablet is predicted by Gartner forecasts, quoted by Halliday (2011), to sell about 48 million iPads worldwide in 2011. This is a near fourfold increase on 2010 and about 70% of the market. The main competition will come from Tablets running Google’s Android operating system. In 2015 sales of Tablets like the iPad are predicted to be about 300 million units- half iPads and half running Android. As more companies offer iPad clones, and assuming production can keep pace with demand, prices will surely fall from the current level of £400+ towards £100+ and at this level every schoolchild in the developed world will want one and probably get one.

The cost of ownership of Tablets like the iPad should be lower than for PCs, since Tablets are inherently more reliable than Laptop PCs because of the absence of moving parts (the major source of hardware unreliability): no hard drive, no physical keyboard, minimal connectors and because, hopefully, of a lesser vulnerability to malicious software. Without a hard drive they rely on access to data stored elsewhere- a networked server or remotely “in the Cloud” but for mathematics learning at least, their memory should be much more than adequate.

Are classrooms like offices?

Nowadays most secondary schoolchildren are familiar with computers and know how to use them. Experience elsewhere in education shows that all learners having their own PCs is not a sufficient condition for learning to occur. Thus, for several years now, university business school students have all had their Laptop PCs- and proudly carried them everywhere around the campus. I asked a colleague what they use them for and he replied “email, games, and social networking, although of course they do use them for Internet research and word processing for their essays”, but the PCs are not used to support learning in any more direct or organised or intensive way than this. Why is this?

Compare this situation with the *organised* use of PCs in office work in the world at large, where nowadays there is a PC in front of every worker and every manager. The software on each worker's PC presents her with a succession of tasks and affords her some autonomy in carrying them out, and records progress. The manager's software monitors workers' progress and alerts her when difficulties- either particular to one of the workers or more generally across her team- occur and need her attention to resolve. An analogy between work in an office and work in a classroom is obvious: *Schoolchildren are learning workers* and *Teachers are class managers.* The change, from a more traditional paper and voice-communication-based office to the modern office organisation with its large scale adoption of IT- a PC in front of every worker and every manager, has occurred quite recently and was achieved across the developed world in a very few years. The outcome has been greatly increased productivity. The roles and interactions of managers and workers have changed significantly but not out of all recognition. There is considerable variation in tightness of management control and degrees of worker autonomy and having some workers based at home, at least for part of each week, is not unusual.

Despite quite heavy investment in IT, the organisation of the traditional learning environment- the secondary school classroom particularly- has changed very little: desks in rows, children writing on paper, teacher up the front- although maybe with an IWB. The driver for reshaping office work was improved productivity. The analogous benefit in education would be improved learning. It is tempting to assume that given the right conditions it would occur.

Is mathematics a laboratory subject?

Mathematics education has been willing to expand its comfort zone and see itself as a lab subject, rather like physics, with classes timetabled as theory, held in an ordinary classroom, or practical held in the PC lab. How valid is the physics analogy? In physics the purpose of the labs (besides teaching laboratory techniques) is for the students to perform milestone experiments: no sound in a vacuum, a prism splitting white light into a spectrum of colours, etc. By analogy a mathematics lab can demonstrate Pythagoras theorem or the graphical solution of simultaneous equations. But the analogy is false. Mathematics is a thinking-and-doing subject with the two actions intimately bound together, whereas in science education a separate presentation of theory and experiment is appropriate: the experiments show the theory has been tested and hence validated. School mathematics has its theory too- its collection of rules- like the associative and commutative laws- but it is much more about developing practical knowledge of mathematical language: how to write it and how to use it. (A mathematics lab has more in common culturally with a modern language lab than a physics lab- except that maths is a written language and language labs have, hitherto, emphasised the aural form.) Because mathematics is a thinking-doing subject, timetabled mathematics laboratory classes are counter-cultural: every maths class ought to be a laboratory class, but unfortunately the technology has so far been too expensive for this to be a reality.

A non-traditional mathematics classroom

SMILE: Secondary Mathematics Independent Learning Experience (Gibbons 1975) was widely used in many schools, mostly in the London area the from the 1970s to the1990s, and is still used, at least partially, in a few schools. SMILE is a system for management of whole-class mathematics learning, while accommodating the needs of individual learners. Learners perform a series of individually allocated mathematical tasks, organized by topic and attainment level, and individual progress is recorded by the class teacher on a grid. Individual allocation of tasks allows children in a class, who have a range of levels of attainment across different topics, to learn mathematics concurrently. The individual tasks have been validated, and in many cases developed, by a generation of dedicated mathematics teachers, who effectively formed a SMILE development cooperative. For each SMILE task there is a printed Card describing the task and a Box containing the materials needed- playing cards, dice, or whatever. Detailed accounts of SMILE in operation at two schools are recorded in (Bartholomew 2001). The SMILE archive (STEM 2011) contains descriptions and materials for about 2,000 distinct Tasks.

SMILE has five components. Two of them: the Database of Tasks and the Grid or Matrix for recording the progress of each child in the class are paper-based. The third is the provision of physical resources- “SMILE Boxes” for tasks. The fourth is a “next-task allocator”- not customarily identified so explicitly: it is expert knowledge stored in the heads of experienced SMILE teachers. The fifth is provision for the child to talk about her task- to the teacher or other learners- to reinforce and extend what is being learned. The strength of SMILE is it treats learners as individuals, its weakness is the substantial learning curve for new teachers while they acquire next-task allocation experience.

Alternative configurations for the maths classroom

The modern version of the traditional arrangement of a mathematics classroom has the teacher in front of an IWB facing her class seated in rows of desks. A class teacher’s time is a scarce resource and so the class is likely to be a set of children of similar maths attainment level, thereby ensuring a small spread of attainment so that whole-class teaching, aimed at the median attainment level, will (hopefully) result in the bottom quartile keeping up and those in the top quartile not getting bored. Whole-class teaching apparently makes efficient use of the teacher’s time. But where this means the teacher is talking and the children are (hopefully) listening, it may not be the optimal way to promote mathematics learning. Learning has a social dimension which can be harnessed in various ways, for example by group projects and by encouraging the children to talk to one-another about their work. The traditional classroom configuration favours the whole-class working in concert, and individuals getting occasional tuition, but it hampers small group interactions.

Ideally a class teacher should be able to optimally allocate the scarce resource which is her time, between the whole-class, small groups, and individual learners. SMILE includes small-group tasks and, in schools where SMILE was established, mathematics classrooms were likely to be furnished with tables- the children working facing inwards- rather than sitting at the traditional rows of front-facing desks (Bartholomew 2001). The SMILE experience shows teachers are willing to adopt a non-traditional classroom arrangement, to facilitate all forms of teaching, if this is approved in their school.

A number of universities (City and Durham for example) have installed IT-equipped facilities for small group interactive working- semicircular tables so that a group can cluster round a laptop PC and with a larger screen display along the straight edge. A networked classroom version could be configured as a hollow square with these small groups around three sides and the teacher's table and IWB on the fourth side: a form of PC lab optimised for small group working.

Tablet mathematics workbook: communicating, storing and interacting

A wireless networked Tablet in front of every child in every mathematics class would be more affordable than PC labs, especially if the children used their own Tablets (and why wouldn't they want to?). But even if the school had to fund the Tablets- at about £100 for the whole of each child's time in secondary education- together with a wireless intranet for the school and a PC for the school server, this would be significantly cheaper than conventional PC labs.

Hitherto, much learning software has been expensive. In contrast with hardware, software costs are all in the development- replication and distribution cost is negligible. Thus the cost of software is amortised over the numbers sold. The annual student cohort in this country exceeds half a million and is an order of magnitude more across Europe and similarly across the English speaking world and more again across the rest of the developed world. This is relevant because the problem of adequate mathematics learning is trans-national and so is the language of mathematics. The annual student numbers are enormous, so if standards for mathematics learning software for Tablets were developed, the prices could be essentially zero and the cost of lifetime-ownership of a Tablet for mathematics learning would be no more than £100 for the Tablet hardware and operating system plus a share of the networking costs.

A Tablet's functionality potentially allows it to behave as a paperless combined textbook/notebook/test-paper/progress-record. Because of the Tablet's communicating and storage properties the textbook can be downloaded from the school server and then stored for use as needed. Because of the Tablet's interactive property, the textbook can also function as a notebook- the learner's working being entered in the appropriate place in the textbook in response to the latter's prompting. Because of Tablets' communicating ability, at a time when a test is due it can appear on the screens of the whole class- to be whisked away to the teacher's or examiner's machine for marking at the end of the test period. The progress/recorder allows all work attempted to be automatically logged and all marks awarded to be automatically entered from the teacher's machine.

With children's Tablets in front of them all the time, all mathematics classes are laboratory classes, and with wireless networking there are no constraints on classroom organization. So much for the learners' Tablets. Teachers Tablets would have class management software, would be able to monitor the progress of every child in the class and could include a task allocator to facilitate support of individualized learning as in SMILE. And the classrooms would be paperless.

Conclusion

The issue addressed by this paper is whether Tablets can improve maths learning. We have seen that a Tablet PC in front of every child in maths classrooms should be affordable and could make classroom learning more, but differently, organized and more intensive, just as modern office work is. Whether such improvement in efficiency in the classroom together with other kinds of support for learners and teachers, potentially offered through the interaction, communication, display and storage properties of Tablets, will help overcome the barriers to learning mathematics so many children seem to have, remains to be seen. We should be optimistic. There is a little time before the wave of Tablet-owning children arrives in our schools. It would be good to get ahead of the game- by using this time for some trials.

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