Characteristics of appropriate use of technology in teaching and assessment

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Abstract

Moore's law (technological power doubles every eighteen months) suggests that training for one particular type of technology will have limited effect as compared to the rapid development of technology. The availability of advanced technology to teachers in the classroom is increasing faster than the ability of many teachers to cope and adapt to new technologies, creating a digital divide between classrooms and between institutions. As many teachers lack formal training in the use of technology, few have had extended contact with new technology, and support for innovation is usually not systematic or practical. Thus, it is not surprising to witness inappropriate use of technology in some classrooms. This paper suggests some basic characteristics of the appropriate use of technology, bringing to light some of the major issues involved in bringing technology into the classroom and perhaps providing a contribution to the development of policies.

Introduction: Should we teach with technology?

'The true way of [mathematical] art is not by instruments, but by demonstration: and that it is a preposterous course of artists, to make their schollers only doers of tricks, as it were juglers: to the despite of art, losse of precious time, and betraying of willing and industrious wits, unto ignorance, and idlenesse. That the use of instruments is indeed excellent, if a man be an artist but contemptible, being set and opposed to art' (Oughtred as quoted in Forster, 2005). That we, as educators, can still ask this question I believe shows a maturity not often found in our contemporary society. The shadow of big technology and big business is always upon us. For some, asking such a question is foolishness and demonstrates how out of touch education is with the real world. Recently, US Secretary of Education Ron Paige attempted to sum up this view, saying that 'education is the only business still debating the usefulness of technology. Schools remain unchanged for the most part, despite numerous reforms and increased investments in computers and networks' (Paige, 2005).

Perhaps the reason technology is not spilling out of school doors is because educators know that 'simply using instructional technology does not guarantee successful student learning or better educational outcomes' (Division of Instructional Innovation and Assessment (DIIA), 2005). In short, education debates technology use because we are not in the business of making cars. We are teaching people, a process some of us believe is slightly more complicated than manufacturing.

While it is true that some countries lag far behind in adopting new technology in the classroom (Oldknow, 1997; Monaghan and Rodd, 2002), most countries are placing cutting edge technology in the hands of students far faster than businesses place cutting edge technology into the hands of their employees (Associate Press, 2005). Educators do so because technology represents a potential to do things differently, and it provides important tools to help learners to learn. We choose technology because we think it helps us reach a particular learning goal better or faster. Thus, the first characteristic of the appropriate use of technology is a teacher who uses technology as a tool to achieve a particular goal or process.

When should we use technology?

Technology generally provides at least two major affordances: representation and communication (Kaput, 2004). The classroom contains the potential for different learning styles, visual, auditory, tactile and kinaesthetic. Gardner (1983) states that 'experiential learning' should be considered in order to offer alternatives and opportunities necessary for success. Teachers should provide opportunities for learning via alternative learning styles, but doing so is often very difficult. Even if the majority of students were auditory, the learning style corresponding to the traditional classroom, teaching only in one style is grossly insufficient. Auditory overloading, especially in second or foreign language situations, is certain to occur in such classrooms as the auditory memory pathways are overworked and crammed with traffic (Owensby and Kolodner, 2002).

Popping up pictures and sounds may help to open alternative pathways for memory mapping. Linked memory related to particular sights, sounds or smells is a well-documented phenomena (Gottfried, 2003; Engen and Ross, 1973). Using visual components in a lecture or encouraging tactile and kinaesthetic experiences with hands on computer-based programs or modelling may enhance the development of representation and communication. At the very least, the lecture will be slightly more interesting and keep student attention longer.

The second characteristic is a teacher who uses technology to enhance representation and/or communication, providing alternative learning styles and possible improvement of memory mapping.

How should we use technology?

Moore's law states that technological power doubles every eighteen months and most institutions upgrade on a three- to five-year schedule. This means that the availability of new technology to the teacher in the classroom is increasing faster than the ability of many teachers to cope. Many teachers lack any formal training in the use of technology and few have had extended contact with new technology (Corbeil and Brown, 2004; Oldknow, 1997; Monaghan and Rodd, 2002).

Technology such as Graphics Display Calculators (GDCs) or Computer Algebra System enabled (CASe) devices evolve even faster than computers and require very specific training that may rapidly become obsolete. Training new teachers for a specific computer program that may become obsolete before the end of teacher training is no better. It seems likely that a newly-trained teacher will face some kind of new technology in his or her very first year of teaching (Corbeil and Brown, 2004, Monaghan and Rodd, 2002). Add to this the heightened set of expectations coming from administrators, parents and the community at large for teachers to make use of technology in the classroom while at the same time improving outcomes. Given the limitations and costs, is it fair to set expectations of teachers so high and how do we make training decisions for teachers?

It seems that a better approach might be to give teachers some kind of grounding for the next level of technology rather than only specific skills in current technology. The critical skills that teachers need are the ones that allow them to transfer themselves between micro-worlds. Teachers need to learn how to evaluate how technology makes their teaching better (or possible in an alternative learning style) and how to improve the enhancement of representations and communication. This requires a grounding in the understanding of the process involved in learning generally, and learning with technology specifically, not just stand alone training in one piece of software or product but the theory of using technology in teaching in general. For example, one could package theory around training in a specific cutting edge technology as an in-service course.

The third characteristic of the appropriate use of technology is a teacher who has been trained in the *theory* of using and evaluating technology, skills that can be transferred to the next evolution of technology (learning how to learn).

How do we assess the learning goal?

We know that technology is creating some major difficulties in assessment, and we know that unbalanced or inappropriate use of technology can seriously disadvantage some students (Corbeil and Brown, 2004). When assessing mathematics and science one has traditionally expected students ‘to show enough of their work for readers to follow their line of reasoning’ (College Board, 2003). But technology results in both students and teachers falling well short of what we traditionally have thought of as ‘answers’. Consider the following example:

> Andrew has 200 dirhams. He buys five energy drinks at 20 dirhams each and one shirt which costs 22 dirhams. How much change should he receive from his initial 200 dirhams?
>
> A typical marking scheme is: $5 \times 20 = 100$, $1 \times 22 = 22$, $100 + 22 = 122$, so that $200 - 122 = 78$. Thus he receives 78 dirhams in change.
>
> Student answer: 78 dirhams. (i.e. no working).

A number of teachers have a hard time giving full marks to a solution that ‘appears’ to lack any support or demonstration. There is this nagging feeling that the student must have cheated or that something fundamental is missing. In short, we judge a student's answer as a product outcome. But, the lack of work on examinations in today's computer or calculator world does not imply that work did not occur. Indeed, a very advanced level of thinking is likely to have occurred via a hand-held device.

In one line on the calculator,

$$200 - (5 \times 20 + 1 \times 22),$$

hit equals and, voilà, 78 magically appears! Students often understand and use technology far better than we do and it should not come as a surprise when they 'out-tech' us. Should we penalise for a lack of working when the student answered the question in a sophisticated technological manner?

It is true that students are over reliant on technology to do what we consider mental mathematics. The history of science and mathematics is full of these funny little examples of critical basic skills that disappear later on. For instance, the following type of problem was once routine in algebra examinations.

> On paper showing all your work (today's euphemism for no calculator), extract the cube root of 113 to four decimal places.
> The solution would require ten iterations of the modified Babylonian algorithm, with about thirty to thirty-five intermediate calculations.

The 'computational medium alters the growth of mathematical content, changes which content is important and for whom, changes the means by which it can be known, taught or learnt, changes the socio-cultural milieu in which teaching and learning occur and in which the institutions of education live, changes the relations between schooling and living . . . ' (Kaput, 1998). If true, does it make sense to maintain subject matter that is trivialised by technology or to award marks for machine answers? It seems obvious that teachers need to be very familiar with technology and identify when, where, and how students use it in the subject.

The fourth characteristic: If technology is introduced into teaching, then the subject and assessment must be adjusted to account for the difference in learning and, then, adjustments must be made to account for the changes that occur to the subject matter.

High stake assessment: Product versus process

We have an infatuation with learning as a product outcome and this may become a serious barrier to the appropriate use of technology (Rogers, 2003). If we wish to adopt new technologies and new ways of doing mathematics in schools then we first must recognise that high stakes assessment is one of the most significant influences on what and how we teach (Barnes, Clarke and Stephens, 2000; Corbeil and Brown, 2004). Time limitations and that final examination are realities of the game. We know it, and act accordingly as any other action would be irresponsible.

Recently, many educators have given some thought to alternative assessment models including project-based teaching and it is not surprising that teachers attempting to use technology in the classroom for the first time find themselves with the same sort of problems as those trying alternative assessment models: time constraints and product outcome-based assessment. Alternatives bring down results and make all involved uncomfortable. The use of technology often does not result in measurable improvement of outcome, or may even have a negative result, especially when using pre-technology assessment models. Can the use of the Personal Digital Assistant (PDA), laptop, or Tablet PC be fairly evaluated within this structure? The question 'tools or toys?' quickly springs to mind and often requires an innovative approach.

Perhaps using product outcome is not a viable method of evaluating technology in education. A slight shift towards process outcomes can help alleviate some of the stress of using project- or technology-based teaching. Blenkin and Kelly (1981) suggest that we evaluate intellectual development and cognitive functioning rather than the quantities of knowledge absorbed or changes. Performance tasks that assess 'processes rather than products', 'approached and planned by reference to the kinds of activities and experience that constitute' the process of learning. Open-ended questions, for example, can illicit impressive demonstrations of subject material.

The introduction of GDCs and CASe devices in high-stakes examinations have had, so far, only a small impact on examination instruments and the main reaction has been to neutralise technology in examinations (Corbeil and Brown, 2004). Open-ended and device-active questions are only two among the many possible alternatives to traditional assessment but this rarely sees the light in mathematics examinations and is practically a non-starter in science subjects. Since assessment is mostly a reflection of institutional leadership, the current status of assessment represents very poor leadership indeed.

Examination boards need to find examiners who are experts and teach regularly with cutting edge technology. The fact is that we want students to demonstrate that they can use the calculator to get answers. Assessment must move away from a basis in the testing of rote manipulation and toward problems that probe an understanding of the fundamental concepts (College Board, 2003). We have plenty of practice with drill and answer, but sparse experience in determining actual subject understanding of a particular student. Perhaps tapping the process of learning a subject may result in a better understanding of this process and better schemata to improve the understanding.

Defining goals as process outcomes as the major feature of the assessment model is the fifth characteristic of the appropriate use of technology.

Who leads and supports teaching with technology development?

It is not surprising to witness inappropriate use of technology in some classrooms. The command from administrators is to use technology. Here the common thinking is 'here it is, there is some training, now go away and get better results!' This is the danger in taking a business model too far into education. In business, it is well know that computer technology traditionally has three almost equally costly parts: hardware, software and training. Failing to account for the cost of one of these will be tragic.

Education, at least the job of teaching, is not a business. In education, we need to add a fourth critical cost: multi-disciplinary, multi-level innovative support. Ask yourself, where does one find the expertise for technology use in my school? From IT? The purpose of IT in an institution is in the support of current and past technology, not development. It is unreasonable to ask them to go cutting edge when today's problems are from yesterday's hardware and software. Teachers are busy teaching and administrators are nervous about using tools that may have negative effects on results (again product outcomes). Examination boards are unlikely to point to any deficiencies in their examination schemes, even though we know that high-stakes examinations drive curriculum.

The innovations seem to come from the so-called 'early adopter' teachers. You can give technology to the early adopter types just like you would add plug and play devices on your computer; plug in and go. Late adopters, on the other hand, represent incompatible and literally unsupported devices. These teachers need serious hand-holding, in-classroom mentoring and organised support, someone who is there the first couple of times to show them where to plug in and how to turn on. Early adopters are usually tapped for help but availability is limited since they are teachers with busy teaching schedules, committees, and papers to mark. Left alone, this is an untapped and diminishing resource. In addition, early adopters are rarely trained in theory and may lack adequate preparation time to consistently use technology appropriately. Early adopters can easily lose sight of the learning goal and have little power to work towards changes in teaching styles and assessment throughout a programme.

The characteristics need to be fused. Leaders (trainers?) in appropriate use of technology need to be trained or experienced in the theory behind the use of technology so they can transfer these skills, as well as specific ones related to the technology at hand. Identifying, supporting and re-positioning these kinds of early adopters is necessary to improve the systematic relationships between users towards learning goals. The learning goals need to be reflected in the adoption of technology but also adaptation of the learning goals must occur as technology is introduced; all this while keeping in mind the process of learning and the importance of opportunities to learn in more than one learning style, interchanging, and active representations.

This relationship then needs to be borne out in the assessment instruments used (and general institutional goals) either by involving the leaders in the process of assessment directly or by making demands that examination bodies adjust assessment to take account of appropriate (but perhaps cutting edge) technology being used in the subject. This means providing support outside of the normal academic structure or creating specialist positions across departments and schools.

Thus, the final characteristic of the appropriate use of technology is an institution's systematic attempt to fuse the basic characteristics into the general instructional principles and policy. Starting with the view of technology as a means to achieve a particular learning goal, work towards having teachers who use technology to enhance representation and learning alternatives, teachers with transferable skills and theory of teaching with technology. The institution should demonstrate systematic accounting of the interrelationship between use of technology, assessment and subject content using subject, assessment and instructional goals defined as process outcomes.

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