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Bridging the Gap: Technology Trends and Use of Technology in Schools

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ABSTRACT

Considerable investment has been made to bring technology to schools and these investments have indeed resulted in many "success stories." However there are two significant gaps in educational uses of technology that must be addressed. The first is a usage gap. Compared to how and how much today's students use technology outside school, in-school technology usage is much less intensive and extensive. The second is an outcome gap. Compared with the outcomes achieved through investment in technology in sectors outside education, the gains in terms reduced costs and increased productivity achieved by schools is significantly smaller. This article discusses the causes of these two gaps and provides suggestions for bridging them by engaging in discussions about effective teaching and committing to technology planning.

Keywords

Educational uses of technology, Usage gap, Outcome gap, Effective teaching, Technology planning

Introduction

The technology investment in schools worldwide has increased more than a hundredfold in the last two decades. Much of this investment has been made based on the assumption that technology-mediated learning environments provide opportunities for students to search for and analyse information, solve problems, communicate and collaborate, hence equipping them with a set of competencies to be competitive in the 21st century marketplace. However, the history of the use of technology in schools has suggested that educators would abandon technology that does not fit the social organization of schooling (Cuban, 2005; Lim, 2007; Zhao & Frank, 2003). In 1922, Thomas Edison predicted that television would largely replace textbooks. In 1932, Benjamin Darrow suggested that radio would challenge the role of teachers and textbooks (Darrow, 1932). In 1984, Seymour Papert forecasted that computer would emerge as the key instructional tool (Papert, 1984). After a little less than a century, schools are still largely reliant on teachers and textbooks.

It is not the intention of this paper to argue that technology has no role in the existing school system or that technology investment in schools is a waste of money. There have been many "success stories" to show that when used properly, technology does lead to enhanced teaching and learning outcomes. In the Second Information Technology in Education Study (Law, Pelgrum, & Plomp, 2008) that involved 28 countries in Africa, Asia, Europe, North America and South America, researchers have shown that technology has been changing classroom practices and learning processes. These transformations include a shift in the role of the teacher from being the sole source of information to a more complex role of negotiating lesson objectives with students, providing a varying degree of support for different students, monitoring students' progress, and encouraging reflection on classroom activities. Students have also taken on a more active role in their own learning process by using technology to search for and collate information, and publish and share their findings. They are now more engaged and are able to make better connections between their previous learning experiences and the new concepts or principles being taught (see e.g., Kozma, 2003). A recent second-order meta-analysis has also revealed low to moderate effect size (around 0.3) of technology on students' achievement (Tamim, Bernard, Borokhovski, Abrami & Schmid, 2011). However, these "success stories" are not a widespread phenomenon in schools (Selwyn, 2008). Unlike hardware, connectivity, and software, the practices and their sociocultural contexts that have led to these positive teaching and learning outcomes have had a difficult time being sustained and spread across classrooms and schools to lead to the promised transformation in schools (OECD, 2010).

Although technologies have not transformed schools in a scale as some might have expected, they have led to irreversible changes in how we work, live, communicate and play. They have led to the development of new

industries, new laws, and new areas of research. Google, Microsoft, Apple, eBay, Amazon, World of Warcraft and Facebook are just a few examples of the magnitude of the importance of these technologies. This paper first aims to examine the gap between technology trends and the use of technology in schools, and then explore alternatives of how this gap may be addressed to transform the teaching and learning processes in schools. The emphasis of the discussion is not on the use of technology per se, but rather on how technology may serve as a foundation and mediator for the transformation of practices in schools. Such transformation is becoming especially urgent given that the activities our students engage in their everyday lives have become distinctly disassociated from the teaching and learning activities in their schools. When this happens, students may find classroom activities meaningless and become disengaged in school.

Modern technology and the way we work, live, and play

Modern technology is not only, as traditionally conceived, a new tool that we use to enhance our lives in the physical world, but has created a whole new digital world. In this new world, we use different technologies to seek and provide resources and information, express ourselves, communicate with others, create, consume, and play, often assuming new and multiple identities. The scope of the digital world is comparable to that of the physical world; from online gaming and online dating to e-learning and e-business. At the same time, the size of the involvement in the digital world is phenomenal and its growth dramatic. There were about 800 million Internet users around the world in 2004. This number had increased to about 1.97 billion as of June 2010 ("Internet," 2011), which is about 28.7% of the total world population.

Work and productivity

Studies have shown the ability of technology in improving productivity saving costs in sectors outside education. For example, a study conducted in 2002 found that the Internet "has already yielded current, cumulative cost savings of US$155.2 billion to U.S. organizations that have adopted Internet business solutions. In addition, these organizations indicate that their Internet business solutions have also helped to increase revenues cumulatively to approximately US$444 billion" (Varian, Litan, Elder, & Shutter, 2002, p. 5). The same study projected that these organizations would realize more than US$0.5 trillion in cost savings once all Internet business solutions are fully implemented by 2010 and "the Net Impact of these cumulative cost savings is expected to account for .43 percentage points of the future increase in the annual U.S. productivity growth rate" (Varian et al., 2002, p. 6). A more recent study of the impact of the Internet focused on the public sector. This 2004 study found that public sector organizations adopting the best identified practices in using the Internet could experience 45% improvement in efficiency, 40% in service volume, 25% in financials, and 55% in citizen satisfaction (Brown, Elder & Koenig, 2004).

Although modern technology may have contributed to business performance, economic growth and customer satisfaction, complementary innovations such as changes in work practices (increased lateral communication and teamwork, empowerment of employees, and revision of processes and workflow) and changes in aspects of products (convenience, quality and variety) have also contributed significantly to these improvements. Most investments in modern technology are usually complemented by organizational investments and the product and service innovation associated with it. When there is no or a lack of organizational changes being made in conjunction with technology investment, there may be significant productivity losses as the benefits from the technology investment may be outweighed by the negative interactions with existing organizational practices (Brynjolfsson & Hitt, 2000). Therefore, the effectiveness and use of these technologies depend on the people, processes, culture and structure of the context in which they are situated.

Live and play

Many people are spending their physical world time living a second or third life in the digital world. A recent study on massively multiplayer online games (MMPOG) found that the current global player populations of three popular game titles (Lineage I, Lineage II, and World of Warcraft) totaled over 9.5 million, which is about the combined total population of New Zealand and Singapore. These games are so compelling because they critique contemporary culture by allowing players to bend or temporarily dismiss social rules in order to try out new ideas and identities

(Steinkuehler, 2006). At the same time, an increasing number of people are merging their physical world life with their virtual one through mobile technology and dynamic websites such as blogs, discussion forums, personal websites, and social networking websites such as MySpace and Facebook.

The digital world is also beginning to penetrate the physical world, as more and more activities are consigned to and performed by means of digital resources. We learn, work, entertain, and stay connected with family, colleagues and friends in a world mediated by technology that has become an essential part of our daily lives. People are seeking real world information from the digital world, as they move away from traditional media such as TV and daily newspapers towards emerging media such as niche news channels and podcasts (Haller, 2005). In fact, traditional media has become increasingly intertwined with emerging media with one complementing the other. For example, in most of the Idols' series around the world (American Idol being the pioneer), they are being screened live on TV but supplemented by the official websites with video and audio links, the "wanna-be" websites, personal blogs of idols and fans, and also by mobile phones from which the short message system (SMS) originated. There is no doubt that in the future our world will be further digitized.

Modern technology and schools

In stark contrast to the great cost savings and improved business performances in other industries, schools may not have reaped as much benefit from the use of modern technology. The practices in many schools around the world have remained very much constant as classroom activities continue to be focused on standards, grades, and outcome measures. Not many schools have become more efficient, that is, operating with less cost, or more effective, that is, enhancing learning outcomes. On the contrary, modern technology may have increased the costs and pressure of running schools in a number of ways. First, in addition to the initial investment in putting technology into schools and wiring them to the Internet, schools have to constantly spend on maintenance and updating the hardware and software. Thanks to the rapidly evolving nature of technology, schools have to not only upgrade software, but also buy new hardware almost every three to five years just in order to keep the same level of access, just as the Red Queen tells Alice in Lewis Carroll's *Through the Looking Glass*: "it takes all the running you can do, to keep in the same place".

Second, schools are under pressure from the media, the public at large and from policymakers to ensure that technology is used for teaching and learning, and that students' learning outcomes are enhanced from the considerable magnitude of investment in technology. Given that a great part of these costs is financed by taxpayers' money, policymakers have the responsibility of ensuring significant returns of investments on technology in schools, hence demonstrating evidence-based policymaking. Some recent studies indicate notable positive outcomes. For example, Harrison and colleagues (2004) in England have statistically significant findings that positively associate higher levels of technology use and school achievement at different key stages in schools. A more recent study by the British Educational and Communications Technology agency, Personalising Learning with Technology, supported these findings but highlighted the challenges of isolating technology among many other factors that might affect school achievement (Becta, 2007).

There are indeed methodological constraints of demanding a high degree of validity and emphasising statistically significant correlations between use of technology and school achievement. Tamim and colleagues' (2011) meta-analyses also supported that learning aided by technology can have positive effects. However, many researchers have pointed out that the use of technology is peripheral to classroom instruction (see Arbelaiz & Gorospe, 2009; Selwyn, 2008; Greenhow, Robelia, & Hughes, 2009). This leaves one questioning the return of investment of technology (or rather, the lack of) after billions of dollars have been spent equipping schools with infrastructure, hardware and software, and training teachers and school leaders in the use of technology. At the same time, with increasing globalization, policymakers are under the pressure to measure these returns based on international benchmarks of school achievement. However, the huge differences between education systems make international comparisons and benchmarking almost impossible.

Lastly, schools are also under pressure to deal with the undesirable uses of modern technology by students. Technology enhances access and processes, and mediates the storage of information and communication with others without differentiating their quality. Thus schools have been drawn into numerous legal, ethical, and ideological battles over the uses and misuses of modern technology. More importantly, they must address the potentially harmful

or distractive effects of technology such as hacking, computer viruses, and cyber bullying. The concern over misuses of the Internet and the potential harm it may bring to students is so grave that many schools have taken an overly cautious approach by limiting access to websites and completely blocking other forms of online activities, especially synchronous communication (e.g., chat) and publishing on the Web (e.g., blogging and access to social networking websites).

These increasing costs and pressure of running schools may take a toll on the way technology is (not) being used for teaching and learning in schools. Like any ecosystem, a school as an organization has the tendency or ability to maintain internal equilibrium. The introduction of new innovations, intentional or unintentional, affects this equilibrium to varying degrees. Using the metaphor of schools as ecological systems, the next section examines why schools have not fully taken up the opportunities of technological innovations for teaching and learning (Zhao & Frank, 2003).

Nature of technological innovations and schools as ecological systems

Almost all technology policies and decisions are about change and often require specific changes in schools, such as reengineering the system and revising learning standards. In addition, technology is universally viewed as a change agent that can catalyze various changes in learning, teaching, and the learning environment. These changes have significant impacts on the organization. For example, a new technology project often requires the installation of new facilities, modification of existing policies or establishment of new policies and regulations, relocation of resources, changes in the informal and formal activities, and may also affect the social relationships of different groups of people (Nardi & O'Day, 1999). In this way, technology innovations introduced to schools are essentially invaders from outside. Whether they can be successfully adopted and become permanently established depends on their compatibility with the teaching and learning environment and the co-adaptation between the technology and the school as an ecological system (Zhao & Frank, 2003).

The school system as an ecosystem consists of diverse components and various relationships that promote or hinder the growth of young organisms within the ecosystem. In the complex sociocultural environment of the school, various groups and processes are closely connected with each other both within and outside the school, and form a network of changes. Similarly, these groups, processes and networks promote or hinder the learning of students within the school. The school is dependent on the other larger ecological systems (for example, the education system and society) within which it is embedded; a change of culture in the broader context, a switch of institutional setting, or an introduction of an innovation is likely to change the learning outcomes of the students. The contexts at different levels may change over time, but they are always interdependent of one another (Lim, Tay & Hedberg, 2011).

Technology as an innovation introduced into schools is not independent and isolated; it is situated in the ecological system of the school and connected to its broader systems. A newly introduced innovation often requires simultaneous innovations in pedagogy, curriculum, assessment, and school organization (Dede, 1998). It also affects the relationships within and outside the school, and the ongoing interaction catalyzes changes in social relationships. Similarly, changes caused by the interactions between an innovation and the school system not only determine how the innovation is adopted, but also affect the operation of the school system. Therefore, the dynamic co-adaptation and co-evolution of students, teachers and school leaders with technology and the system determines whether the opportunities of technology for teaching and learning can be realized in schools (Zhao & Frank, 2003).

The gap between the technology trends and use of technology in schools

The healthy co-adaptation of technology and the school system is influenced and constrained by many conditions. These conditions may be related to school technology resources, school culture, readiness and experiences of teachers and students regarding using technology, and the dynamics of the social interactions in the school system (Byrom & Bingham, 2001; Zhao, Kevin, Stephen, & Byers, 2002).These conditions are interdependent of one another, and their impact on technology implementation is beyond a simple and linear one. On the contrary, they are entangled with each other, their influence varies from case to case, their interactions and relationships change as the school environment evolves with the technology implementation, and the changes are situated in local contexts (Zhao & Frank, 2003). The school context gradually evolves, changing the characteristics of teachers, students, and

their technology uses, which further changes the challenges the school faces at different stages. Since technology use in schools constantly changes along with all of the other elements of the ecosystem - the users, the school system, and the relationships between these subsystems - there is no "once and for all" solution to technology implementation in schools. A technology implementation plan that works at one time may not work at another, so a dynamic plan that reflects changes will work better than a static plan (Tondeur, Van Keer, van Braak, & Valcke, 2008).

Even if a technology project has been successful, to continue its successful implementation, new policies need to be made, more money needs to be spent on upgrading software and updating hardware, more appropriate help needs to be provided to both teachers and students, and more investment needs to be put into sustaining and improving sufficient technical support—while all these changes depend on strong leadership. So it is important to provide ongoing technology planning and evaluation, to continuously revise and refine current practices, and provide timely support (Tondeur, Van Keer, Van Braak, & Valcke, 2008).

However, even if all the necessary conditions are in place, it is still difficult to judge the success of technology implementation because there is still a lack of specific goals or models to emulate. Although researchers have repeatedly suggested that successful policy implementation requires clearly defined goals directly connected to student learning (e.g., Fullan, 2001), no specific educational goals are defined in educational technology policy documents except for tangible intermediary goals such as amount of hardware, student- computer ratios, and connectivity rates. In a paper that reviews educational technology policy over the last 20 years, Culp, Honey and Mandinach (2005) identify six major goals/recommendations that have remained highly consistent over time, but none of them are about the educational outcomes of technology investment.

Although specific quantitative data (such as numbers, percentiles, and test scores) are commonly used in policy documents to demonstrate the current "crisis" in education and to justify the need for technology, no quantitative goals or outcomes are specified. Even if student outcomes are mentioned, it is done using vague and unmeasured terms. A convenient criterion for measuring student outcomes is student academic achievement. However, it is very difficult to establish causal relationships between technology use and student academic achievement, because student achievement is influenced by many factors. The impact of technology use on student outcomes is not determined merely by the particular technology uses, but rather is mediated by environmental factors, the users, and the constantly changing interactions and mutual influences. In addition, the use of technology in schools is part of a complex network, and changes in classroom technologies correlate to changes in other educational factors (OECD, 2010). Thus it is unrealistic to assume simple cause-effect relationships or to expect dramatic changes in student performance through one or two specific technology projects. Consequently, schools can only guess what is expected from their technology investment.

Most school leaders do not have a clear sense of how to evaluate effective use of technology (Russell, Bebell, O'Dwyer & O'Connor, 2003), and teachers do not know much about their schools' vision for the use of technology in their classrooms (Russell & Higgins, 2003; Tondeur et al., 2008). Due to the lack of sound understanding of the specific goals of technology integration, the use of technology per se may have become the goal in many cases. Schools, as well as educational technology research, often turn to how much time students spend using technology and what technology is available as indicators of successful technology integration, but do not measure whether or not, or how, technology is being used in meaningful ways in teaching and learning (Lei & Zhao 2007).

Bridging the gap

Defining effective teaching

There is no clear indication or widely used measurement of effective teaching. Although some research studies have attempted to use students' academic performance outcomes as a significant indicator of the effectiveness of teaching, these studies have been controversial and open to debate. It is controversial because it is seen as a vehicle to promote an education system that has been creating inequalities of social and intellectual capital. It is open to debate because effective teaching is one of the many variables that may affect students' academic performance, and there is no agreed-upon definition of effective teaching (Campbell, Kyriakides, Muijs, & Robinson, 2004). This is especially pertinent in the discussion of the use of technology and how it may enhance the effectiveness of teaching.

This may be further complicated by other terms such as school effectiveness, school improvement and teaching quality. Campbell and colleagues (2003) review the research on teacher effectiveness and identify three problems associated with the current concepts of teacher effectiveness. The first problem is the conceptualization of teacher effectiveness itself. The second problem is the relationship between school effectiveness and teaching effectiveness. There could be effective teachers in ineffective schools and ineffective teachers in effective schools, and therefore the relationship between school and teacher effectiveness is becoming problematic. We need to consider that the effectiveness of the school may help teachers to do a better job and thus teaching becomes more effective. For example if the school provides a conducive learning environment and a good technology infrastructure, is there a likelihood that teachers can try out new approaches that would engage students in the subjects they are teaching.

The third problem with the teaching effectiveness research is that while the research is analytical and lists the characteristics of effective teaching, it fails to inform teachers how to move from ineffective to effective practice. According to these studies, the narrowness of the operational definition is also causing problems; the definition should not be limited to the cognitive aspect only, but should include other aspects such as affective and moral values. Campbell and colleagues (2003) also pointed out that current teacher effectiveness studies tend to provide a set of characteristics that measure the teacher behavior, knowledge and beliefs, without considering the context and the levels at which they are teaching.

Shao, Anderson and Newsome (2007) reported the views of faculty members in their study regarding teaching effectiveness indicators. The respondents were asked to rate the importance of twenty general items that are commonly used to evaluate teaching effectiveness. They found that student evaluation scores, student written comments and teaching awards ranked highest, and that use of technology was not ranked at the top. From the literature review, it is noted that many instruments developed to measure the teaching effectiveness dimensions are diverse and inconclusive. Burdsal and Harrison (2008) propose that a multidimensional profile should be used to provide evidence for the overall evaluation of teaching effectiveness.

While the debate is still going on regarding the operational definition of teaching effectiveness, another set of questions is asked about the relationship between the use of technology and educational quality. Johannessen (2009) observes that we are increasingly using technology in all facets of our lives and we need to look at the question of whether the use of technology improves students' performance. He urges carefully selecting the indicators related to the use of technology that reflect the integration of new applications. School systems have been putting financial resources into technological infrastructure, and he suggests developing a knowledge base in search of evidence of the effective use of technology. It is becoming clear that providing technology to schools or teachers will not necessarily make a difference. But the way technology is used by teachers and students may make a difference.

ICT planning

Another cause of the mismatch between technology trends and the use of technology in schools is the lack of technology planning. In a technology policy plan, a school describes its expectations, goals, content and actions concerning the integration of ICT in education (Vanderline, van Braak & Tondeur, 2010). This includes elements such as vision building, professional development, and evaluation. While schools have been procuring hi-tech equipment with the aim of introducing the latest technologies in teaching and learning, the results are not clearly visible either in terms of acceptance by the teachers or in students' learning outcomes. Gulbahar (2007) notes that technology integration is a complex process and a demanding task for teachers and school administrators. In her study, she found that even teachers and administrators who felt themselves competent in using ICT reported that there was a lack of guidelines that would lead them to successful integration. Tondeur and colleagues (2008) confirm the importance of technology planning in schools. They found in the survey that ICT planned together with ICT support and ICT training has a significant effect on classroom use of ICT. They have also pointed out that school policies (in relation to ICT) are underdeveloped and underutilized. The results lead us to believe that a shared and school-wide vision of ICT is needed to succeed in technology integration.

Anderson (1999) noted that technology planning is a process of developing, revising and implementing technology plans in order to guide organizations to achieve their goals. A technology plan also describes the learning objectives, how the technology will be used and how it will be evaluated. According to Fishman and Zhang (2003), technology plans are the interface between research and development in learning technologies and their actual use in schools.

They present four characteristics of successful planning for technology. The first to be considered is using the technology plan as a policy document. A technology plan is usually devised at different levels of administration. At the highest level, such a plan can be considered as a blueprint for all stakeholders including educational planners, mid-level supervisors, and school level administrators. Secondly, this policy document would trickle down to teachers at the classroom level. A technology plan then exists at multiple levels and has multiple purposes.

Thirdly, a technology plan is never static. As technology changes rapidly, the plan to use technology also needs to be flexible and adapt to the circumstances. Fishman and Zhang (2003) note that a common error made by schools that have developed a technology plan is the assumption that the planning document is the end of the process. The evolving nature of technology requires constant adjustment to and revisiting of the plan. Such adjustment and revisiting not only allow teachers to make a better alignment with new technologies, but also help to adjust the changing learning environment and social context. The fourth characteristic is that any successful technology plan requires commitment, support and collaboration at different levels. It is important to establish a relationship with schools and outside organizations such as teacher training institutions and the corporate sector. Much needed help can be gained by having close connections with these organizations.

Implications and conclusion

The speed with which the revolution of technology has taken place is phenomenal. As stated before, teachers in many countries of the world are working with 'digital natives' who are growing up with technology as a non-remarkable feature of their world, in the same way as an earlier generation took radio or television for granted. Within these developments, technology brings a new set of challenges and pressures for educational institutions. Many teachers, schools, educational authorities and researchers are considering a range of questions about how to use technology within classroom practices: What educational goals and learning objectives will be accomplished by using technology in schools? Is there a need for a specific course in digital literacy? How can technology be integrated effectively in existing subjects? Many of these questions are still unanswered, and attempts to address them have generated widespread debates.

Clearly, effectively integrating technology into learning systems is much more complicated than for example providing computers and securing a connection to the Internet. Computers are only a tool; no technology can fix an undeveloped educational philosophy or compensate for inadequate practices (Ertmer, 2005). Therefore, choices have to be made in terms of educational objectives (Sugar, Crawley, & Fine 2004). In this respect, the process of technology integration is a dynamic one involving interacting factors over time (Tondeur et al., 2008). Moreover, no single solution exists to address the immense challenges of technology integration because different perspectives of integrating technology can be chosen.

Several studies have pointed at the critical importance of national policies in promoting the potential of technology in learning processes (e.g., Tawalbeh 2001; Tondeur, van Braak, & Valcke, 2007; Lim, 2007). However, the definition of a national curriculum on its own does not guarantee any instructional use of technology (Goodison, 2002). An interesting issue in the context of this discussion is the balance between the extrinsic and intrinsic forces that drive the integrated use of ICT by teachers. Imposing policy decisions is often less responsive to teacher perspectives and often neglects workplace constraints. A way forward is stressing the responsibilities of local schools to develop a school-based technology plan.

In a best-case scenario, such a plan will stimulate a dialogue among school managers, teachers and parents about technology use in the curriculum. Moreover, engaging teachers in the development of policy planning gives them the opportunity to reflect on their particular educational use of technology. It fosters the subjective meaning-making process of individual teachers as to how and why they will respond to technology use in class. In the context of this dialogue, the following questions can be explored: How can technology be integrated and tested in classroom practice? What feedback can be derived from classroom practice? What type of feedback is considered critical from a classroom perspective? As technology continues to drive changes in society and in education, we contend that such policies need to define their organisational vision and actions more clearly in view of planned change.

It is clear that technology integration is not yet achieved in a systemic or systematic way in most schools. Very few schools can be labeled as "learning organizations" with a shared commitment to technology in education. In this

respect, the literature about school improvement stresses the importance of leadership in developing a commitment to change. Their capacity to develop and articulate, in close collaboration with other actors from the school community, a shared vision about technology use is considered a critical building block in this process. An important implication, therefore, is that the training of principals should become a priority in developing technology-related professional development. The studies by Dawson and Rakes (2003) and Lawless and Pellegrino (2007) underpin the former: the more professional development principals receive and the more engaged they are in the professional development of their teachers, the more technology integration at school level is observed. Their findings suggest that without well-trained, technology-capable principals, the integration of modern technology into school curricula will remain deficient. This perspective adds to the holistic approach when exploring the gap between technology trends and use of technology in schools because teachers are not considered as completely independent, but share their context.

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