Trends and Research Issues in Educational Technology

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ABSTRACT

If one looks back at the last 50 years or so at educational technologies, one will notice several things. First, the pace of innovation has increased dramatically with many developments in the application of digital technologies to learning and instruction, following by a few years developments in the sciences and engineering disciplines that are largely responsible for the rapid growth in information and communication technologies. Second, advocates of new educational technologies have been overly enthusiastic in promising dramatic improvements in learning and instruction, in part due to the success of new technologies in transforming other sectors. Third, the levels of public and governmental support of educational technology have fallen far short of how technologies have been supported in other areas. These remarks represent a critical review of what appear to be the most promising educational technologies and the challenges these technologies bring to society, and especially to educational researchers. This is by no means a rigorous or comprehensive review. Rather, these remarks are simply those of someone who wishes to better support learning and instruction using appropriate methods and technologies.

Keywords: *Assessment technologies; Emerging technologies; MOOCs; Personalized learning; Serious Games*

INTRODUCTION

Let's begin with a few definitions and orienting comments so as to develop a common understanding of challenges and issues. First, learning can be defined as a process that, when successful, is characterized by stable and persisting changes in what a person, or group of people, know and can do. Learning is fundamentally about change – change that endures. To argue that a change has occurred, one must have a baseline measure with which to begin, such as a pre-test of knowledge and ability in a particular area. Then, one must have a compatible measure taken after an instructional sequence or educational experience. Is that sufficient? Not if one is serious about learning involving stable and persisting changes. One must then also have measures taken long after an instructional sequence or educational experience – at least three months afterwards and preferably again after a year or more.

This should be obvious but establishing evidence of learning in the sense just described is all too rare. We do this with our children. We spend a day or two teaching a young child to ride a bicycle. Typically the child falls off initially but soon gains a sense of balance and confidence and proceeds to master the bicycle. Years later, even after long periods of not riding a bicycle, that child is still able to ride without falling. One can find similar examples with regard to intellectual skills such as reading or doing arithmetic. In these and other cases, it is worth noting that the relevant measurement involves what academics would call an authentic assessment – namely, performing the task to demonstrate that learning has occurred and not faded significantly over time. Keep an eye and ear out for more about authentic tasks and assessments with regard to emerging technologies. Technology has much to promise in this area.

What, then, is technology? Shall we limit the discussion to the so-called hard technologies that one can touch? That is the common, ordinary language use of the term 'technology', and in the world of educational technology what then comes to mind are personal computers, laptops, tablet computers, smartphones and such things. What about the Internet? Can one touch the Internet? One can certainly experience the Internet. What about sending messages and exchanging files and engaging in audio and video conferences using the Internet? Again one can experience all of those things and more, and they involve a number of protocols – established procedures – to support those experiences. So, we should include established procedures, algorithms, protocols, and other such things as kinds of technologies. A broad characterization of technology is that technology is the systematic application of knowledge (e.g., science and engineering) for a purpose (typically aimed at benefitting society or a particular group or organization). Technology is the purposeful application of knowledge.

Technologies change as knowledge advances, as one would expect. Technology changes what people do and what they can do, which one would expect of the purposeful application of knowledge. Sometimes people make unexpected uses of technology, which is an issue that designers should take into account. The point here, however, is that an essential attribute of technology is change, just as it was for learning. To understand a particular technology, one needs to be able to understand what activities, tasks, procedures, and processes are changed and how they are changed. The introduction of propane and electrically powered refrigerators created many changes (Spector, 2012). Delivery of ice blocks gradually faded away as a standard practice. New things had to be learned, such as defrosting early refrigerators periodically as automatic defrosting as a technology took some time to develop. Anticipating and preparing for such changes is an important but often overlooked aspect of the effective use and dissemination of technology, especially in the world of educational technology. One ought to realize that new educational technologies being deployed in schools and universities typically bring requirements for capital investment, training personnel, and revising policies and procedures. Schools and universities often have limited resources. Moreover, it is not very practical to expect an academic teacher to learn to use and integrate a new technology every year in his or her practice. Which technologies are likely to have a significant and sustained impact on learning and instruction? What are the costs associated with those benefits?

The goal is to use technology to support and facilitate learning and instruction. That is a core task for an educational system. Just as technology is the purposeful application of knowledge to benefit individuals and society, education is the purposeful development of knowledge and understanding to benefit individuals and society (Dewey, 1910, 1938). The goal is to make learning engaging, effective and efficient. A fourth 'e' – 'entertaining' – is intentionally omitted although many have written about *edutainment*. Learning need not be entertaining; it is important to maintain a strong distinction between entertainment and learning, which is not a popular view. What matters is that learning occurs, and learner engagement with content, concepts, problems, principles and such is important, as is learner motivation. Entertainment and fun are secondary albeit occasional motivators and interest generators.

General Research Concerns

Educational technology research falls into the general category of applied research. The basic approach is to take what basic research has established in areas such as the psychology of human learning and apply basic research findings, associated theories and prior applied research findings to improve learning and instruction with [and sometimes without] technology. Typically, an intervention of some kind involving technology is involved in an effort to resolve or improve a problematic situation involving learning, instruction, training, performance improvement. The problematic situation could involve one or more processes involved in planning, implementing, deploying, managing, or evaluating an application of technology to improve learning, instruction or performance. This means that a typical case involves an investigation of how well and to what extent the intervention was effective.

In such an investigation there are many kinds of research that can be involved. Driving a planned intervention there is usually a theory of change based on prior research and theory. That theory of change can be expected to answer the question: "Why should one expect this intervention to transform the problematic situation into a more desirable situation?" Such a question can be addressed in an analysis of relevant research and theory paper or what might be called a conceptual framework paper.

Because new technologies are often involved in an intervention, it is often appropriate to follow a conceptual paper with an exploratory empirical study. Such a study might be aimed at exploring what happens when a new technology is introduced into a particular situation. Typically such a study is descriptive in nature and might involve surveys, interviews, analysis of artifacts, and such things. Case studies are often used in this way, although they are also used to investigate more mature applications of technology in learning and instruction. The point of exploratory research is often to determine the relevant variables and factors to investigate when refining and deploying an application in a wider context.

Another kind of research question that one often encounters in educational technology is why things seem to happen as they do. For example, an exploratory study might have suggested that students like the flexibility of online learning and appreciate the affordances of social networking within a particular academic context. However, when one begins to investigate learning outcomes, the results are less promising. Why? Answering such a question usually requires more rigorous research than the descriptive methods used in an exploratory study. While such investigations are often supported with quantitative methods and inferential statistics, one often finds it worthwhile to include qualitative methods to gain deeper insight to what students are doing and thinking about while in a learning environment.

Yet another kind of study involves investigating a what-if question such as this: What if we replace lecturing with off-line directed readings and activities and use the lecture to support collaborative problem solving activities? Will learners spend more time reading assignments? Will problem-solving performance improve? Will learning and understanding be enhanced? Answering such questions often requires a number of studies; it is possible to construct an entire research agenda around such questions.

To conclude these general remarks, it is worthwhile to remember that one should keep in mind the overall goal or aim (e.g., resolving a problematic situation or improving learning and instruction). In addition, one should proceed with an open mind and follow the evidence wherever it leads. Next, one should establish the problem and research questions first, and then select appropriate research methods and design to address that problem and those questions. Finally, one should realize that there are values to be considered in any research endeavor. Here are a few such values expressed in an *Educratic Oath* (Spector, 2005):

a) Do nothing to impair learning and instruction;
b) Do what you can to improve learning and instruction;
c) Base your actions on evidence that you and others have gathered and analyzed;
d) Share the principles of learning and instruction that you have learned with others; and,
e) Respect the individual rights of all those with whom you interact.

Emerging Technologies

What then are the new and emerging technologies that show promise and potential for learning and instruction? Where might one look to find an answer from reliable and credible sources? Here are such sources:

- The New Media Consortium's *Horizon Report* (see http://www.nmc.org; NMC, 2013)
- The National Science Foundation's *Roadmap for Education Technology* (see **http://www.cra.org/ccc/edtech.php**; Woolf, 2010)
- The European Network of Excellence for Technology Enhanced Learning (see **http://www.stellarnet.eu/**; STELLAR, n.d.)
- The European Network of Excellence for Serious Games (see **http://www.galanoe.eu/; GALA, n.d.)**
- The IEEE Learning Technology Technical Committee report on curricula for advanced learning technologies (see http://www.ifets.info/journals/13_2/ets_13_2_contents.pdf; Hartley et al., 2010)
- The *Handbook of Research on Educational Communication and Technologies* (editions 3 and 4) (see http://aect.site-ym.com/?page=handbook_of_research; Spector et al. 2008; Spector et al., 2013)
- A *National Educational Technology Plan* (see http://www.ed.gov/technology/netp-2010; NETP, 2010)

Other such sources can be identified, but these are sufficient to establish a common area of agreement that is not based on commercial interests or the overly enthusiastic opinion of a few advocates of a particular technology. When then do such sources indicate?

The *Horizon Report: Higher Education Report for 2013* (NMC, 2013) is a good point of departure as it contains trends, promising technologies divided into near-term, mid-term, and long-term areas along with a number of challenges. Moreover, one can compare the 2013 report with prior reports to gain a deeper insight into technology trends and issues. In this section, only the technologies will be reviewed as trends and challenges are treated separately in subsequent sections.

The near-term technologies to watch according to the *Horizon Report* (NMC, 2013) are MOOCs (Massive Open

Online Courses) and tablet computers. Mid-term technologies to watch include games/gamification and learning analytics. Long-term technologies include 3D printing and wearable technologies. According to the *Roadmap for Education Technology* (Woolf, 2010), important new technologies for education include: user modeling, mobile tools, networking tools, serious games, intelligent environments, educational data mining, and rich interfaces. One can already see a great deal of overlap, and if one looks at prior *Horizon Reports* from 2010 to 2013, the overlap is even greater. The *Roadmap* includes important enabling technologies (e.g., user modeling and rich interfaces) that are vital to implementing such things as MOOCs and Serious Games.

The two large-scale European Networks of Excellence (GALA, n.d.; STELLAR, n.d.) provide a number of additional tools including social network analysis tools and standard research instruments that have been validated and can be freely and easily shared. These networks of excellence also provide a rich set of resources on their Websites – a genuine effort to support and sustain scholarly inquiry and scientific investigation.

A recently released technology causing much stir in the media is Google Glass (see http://www.google.com/glass/start/). The *Horizon Report* (NMC, 2013) puts this in the far-term category of wearable technologies. This is a wise categorization in spite of all the current hype. All too often educational technologists become overly enthusiastic about a new technology and advocate its widespread use beyond what any evidence or careful analysis can substantiate. In part because technology changes so rapidly, it is in the nature of an educational technologist to explore new technologies and push the use of new technologies to improve learning and instruction. However, it is important to remember the prime directive – help people learn better and do that without causing harm. Schools often have limited resources, and teachers are often overworked. Pushing a new and untested technology into practical setting every year may not help people learn better and may cause some harm. It is best to proceed with caution and with evidence.

Along the same lines, MOOCs have gained traction in education in a remarkably short period of time without evidence that learning or instruction is significantly improved. The idea of MOOCs is clearly appealing to some universities and schools, but the actual implementations leave much to be desired, particularly in the area of dynamic formative feedback and personalizing instruction to fit specific learning needs (Daniel, 2012).

Games and gamification are also receiving a great deal of enthusiastic support, although the evidence of learning improvements are largely limited to games for children in which the game goal is closely aligned with the learning goal. Games do have the added advantage of promoting interest in a discipline area and enhancing motivation when appropriately implemented (Tobias & Fletcher, 2011).

A third technology cluster can be gleaned from these sources – namely, personalized learning. This may well be the most promising new technology with the potential to have the greatest impact. It is not a near-term technology, although the idea is far from new. One-on-one human tutoring has long been known to have a significant impact on learning (Bloom, 1984). In the 1980s, there was a significant effort to achieve what Bloom envisioned through the use of what was then an emerging technology – namely, intelligent tutoring systems (ITSs). There was some limited success with some ITSs when they were constrained to very well defined learning tasks that had obvious sets of common errors and an obvious path from simpler to more complex problem solving tasks. However, the ITS movement did not live up to the promises that many advocates made of an across the board two standard deviation improvement in learning regardless of domain or level.

Why did ITSs fall short of the promises made? First, insufficient attention was given to the different kinds of problems that needed to be solved, many of which were ill-structured, complex, and dynamic making the creation of an ITS quite difficult. Second, learner modeling was based primarily on learner performance in that learning environment and not on a larger understanding of a particular learner and learning context. Third, there were no data to use in determining how best to address a particular student's difficulties (Spector, 2008).

We can and should learn from past experience and especially from failures. What appears to be the case is that technologies now exist that can create effective technology-centered personalized learning environments. As the various sources suggest, learning analytics, user-modeling and rich interfaces, among others, can be used to customize learning activities and resources and provide dynamic formative feedback to support individual learning needs. A particular challenge is the need to further develop the means to provide just-in-task, just-when-needed, constructive, informative feedback to learners, especially with regard to challenging and complex learning tasks (Pirnay-Dummer, Ifenthaler, & Spector, 2010; Spector & Koszalka, 2004).

Trends in Using Technologies in Education

How might the trends with regard to recent and emerging educational technologies be characterized? Again it is possible to examine the sources previously mentioned to gain insight. The *Horizon Report* (NMC, 2013) mentions such trends as these:

- More open content, data, resources, and access, as exemplified in MOOCs
- Increase demands from business, industry and the government for more informal, work-related instruction delivered online
- New sources and methods to support personalized learning (as previously emphasized)
- Changing roles for educators and changing educational paradigms (one should not expect such changes to happen quickly or easily, although that is a common assumption of many educational technologists)

The *Roadmap for Education Technology* (Woolf, 2010) identified similar trends, including: (a) more personalization of education, (b) more emphasis on assessment, and (c) increasing emphasis on socially-situated learning. The two European Networks of Excellence previously mentioned (GALA, n.d.; STELLAR, n.d.) both indicate a trend towards connecting learners and teachers, more emphasis on networked learning, more virtual learning environments and games appropriately contextualized, and more standardization of instruments and resources.

A more generalized summary of recent trends in educational technologies includes:

- Smaller, more portable and more flexible devices to support learning (a combination of several of the categories found in the sources previously mentioned);
- Larger and more powerful data sets and information repositories (e.g., as indicated by learning analytics and other technologies previously mentioned);
- Richer educational environments (richer in terms of resources, delivery methods, learning activities, interfaces, and so on); and,
- More holistic approaches to the use and integration of learning and associated evaluation and research efforts (Spector, 2005, 2008, 2009, 2012).

The last item deserves elaboration as it has not been previously discussed in this paper. One can distinguish two basic orientations in using and assessing technology in education: an atomistic approach and a holistic approach (Spector, 2005, 2012). Each has its strengths and weaknesses. The atomistic assumes the appropriate focus is a particular learning objective or outcome and the appropriate units of analyses are the unit of instruction involved and an individual learner. The underlying assumption is that the lesson is reasonably well designed, although this might be the focus of a study. Learners are assumed to behave rationally. That is to say that a learner can identify and correctly interpret the learning goal or objective, that the learner can then identify alternative means of achieving the desired outcome, and the learner will select an optimal path to the goal. This approach lends itself nicely to situations involving summative assessment of individual learners, summative evaluations of a learning environments, and/or high-stakes testing. Weaknesses of this approach include the fact that the learner's goal may differ somewhat from the intended learning goal (e.g., pass the course and escape to a different discipline rather than master the content and proceed to higher levels in that discipline), the learner may not always behave in a rational manner (sometimes preferences and habits lead one away from a path of pure rationality), and the way that many learners come to understand the world is in collaboration with others.

The overall trend seems to be towards a more holistic approach to learning, technology integration and education research. In such an approach, the units of analyses might include learning groups or teams, teachers and other support persons, and a much larger view of what counts as a unit of instruction that embraces many more resources and activities than previously considered. The focus includes not just learning gains, but shifts in interests and preferences, the selection of follow-on courses, and the development of higher-order thinking and reasoning skills. Such an overall trend reflects a dual emphasis on personalizing learning (especially with formative feedback just when needed in solving problems alone or in collaboration with others) and on connecting learners to other learners, information sources, supportive resources and activities, and other areas to explore.

RESEARCH CHALLENGES

Technologies change. Educational and training situations change. Learning approaches change. What does this mean for those conducting research with regard to educational technologies? It is undeniably the case that the task of designing effective instruction has become increasingly difficult as a result of all of the changes previously mentioned. The more resources that are available, the greater the challenge in selecting, sequencing and suggesting appropriate resources to support learning. The greater the ability to communicate easily, affordably and immediately with others, the greater the challenge in supporting and orchestrating collaborative learning activities. Unfortunately, the increasing challenges confronting instructional designers are all too often overlooked in policy making and high-level planning discussions.

Universities are slow to change or develop new curricula. There are two things to add to this remark about the increasing complexity of instructional design. Curricula need to change to properly prepare instructional designers for the 21st century (Hartley et al., 2010). Curricula that develop competencies (related sets of knowledge, skills, abilities and attitudes) with regard to (a) knowledge about advance learning technologies, (b) understanding how people learn and what effects different technologies have on learning, (c) applying specific technologies to improve learning and instruction, (d) developing the ability communicate and collaborate with a variety of people with different backgrounds, and (e) acquiring and refining complex problem-solving skills and becoming more flexible and creative designers and thinkers.

In addition to revising instructional design curricula, teachers need to prepare much differently than is currently standard practice. Presently, all too many technology integration courses for pre-service teachers simply present a particular technology, instruct teachers in operating that technology, and suggest a few general kinds of educational applications. What is lacking is systematic development of a per-service teacher's ability to effectively connect the use of a particular technology with a learning goal, with knowledge of how students learn, and with the content to be mastered. When technology integration is most effective, the learner's attention and focus is not on the technology involved but, rather, on the concepts or knowledge to be learned. Moreover, teachers need to be trained in teaching learners how to integrate technology into their own learning activities. These areas in many teacher preparation programs are often neglected.

Likewise, the challenges confronting those who are conducting research with regard to educational technology implementations, technology integration in schools and universities, and instructional design methods and techniques have also increased dramatically in the last twenty years. One research challenged cited in the *Horizon Report (*NMC, 2013) involves the publication of research. As information and communications technologies evolve, new forms of scholarship, authoring and publication are also emerging. Keeping up with published research becomes a serious research challenge now more than ever before. In the not so distant past, one could look to a few research journals for relevant research on which to build. Now, a responsible researcher needs to look at 20 or more journals to be sure that the most relevant research findings are including in the background research.

The *Roadmap for Education Technology* (Woolf, 2010) emphasizes research and development in seven areas: (a) personalizing education, (b) assessing student learning, (c) supporting social learning, (d) diminishing boundaries between working and learning, (e) alternative teaching methods, (f) enhancing the role of all stakeholders in applications of new technologies, and (g) understanding how policies affect learning, instruction and the adoption of new technologies. The *National Education Technology Plan* (NTEP, 2010) urges research and development aimed at: (a) the adoption of cost-effective strategies to improve learning outcomes and graduation rates, (b) embracing innovation, prompt implementation and continuous improvement, and (c) leveraging technology to provide engaging, powerful, and authentic learning experiences. Those high level research and development goals are consistent with the trends outlined in the Horizon Report (NMC, 2013) and the *Roadmap for Education Technology* (Woolf, 2010).

The European perspective on research challenges, as reflected in the two networks of excellence previously mentioned (GALA, n.d.; STELLAR, n.d.) including developing standard research tools and instruments so that research findings can become cumulative as is the case in other areas of scientific investigation. Those projects also emphasis new tools and associated research methods to accompany those tools, as with social networking and social network analysis methods and tools.

Some things do not change, however. Research and evaluation efforts can still be guided by a logic model. A logic model is based on the notion that an educational technology application or intervention is designed to transform a problematic situation into a desired situation (e.g., from a 75% graduation rate to a 95% graduation rate). Associated with such an effort is an analysis of the problem situation (e.g., a needs assessment) and a review of situational factors, constraints and assumptions. A plan of action is then development that specifies a theory of change and a solution approach, including inputs to be influenced, controlled or manipulated by the intervention along with details of how the implementation will take place. The plan is implemented (this could involve multiple iterations as in design-based research), and the implementation is evaluated (e.g., a fidelity of implementation study or ongoing formative evaluations) as well as the outcomes (e.g., an impact study or a summative evaluation) (see Figure 1).

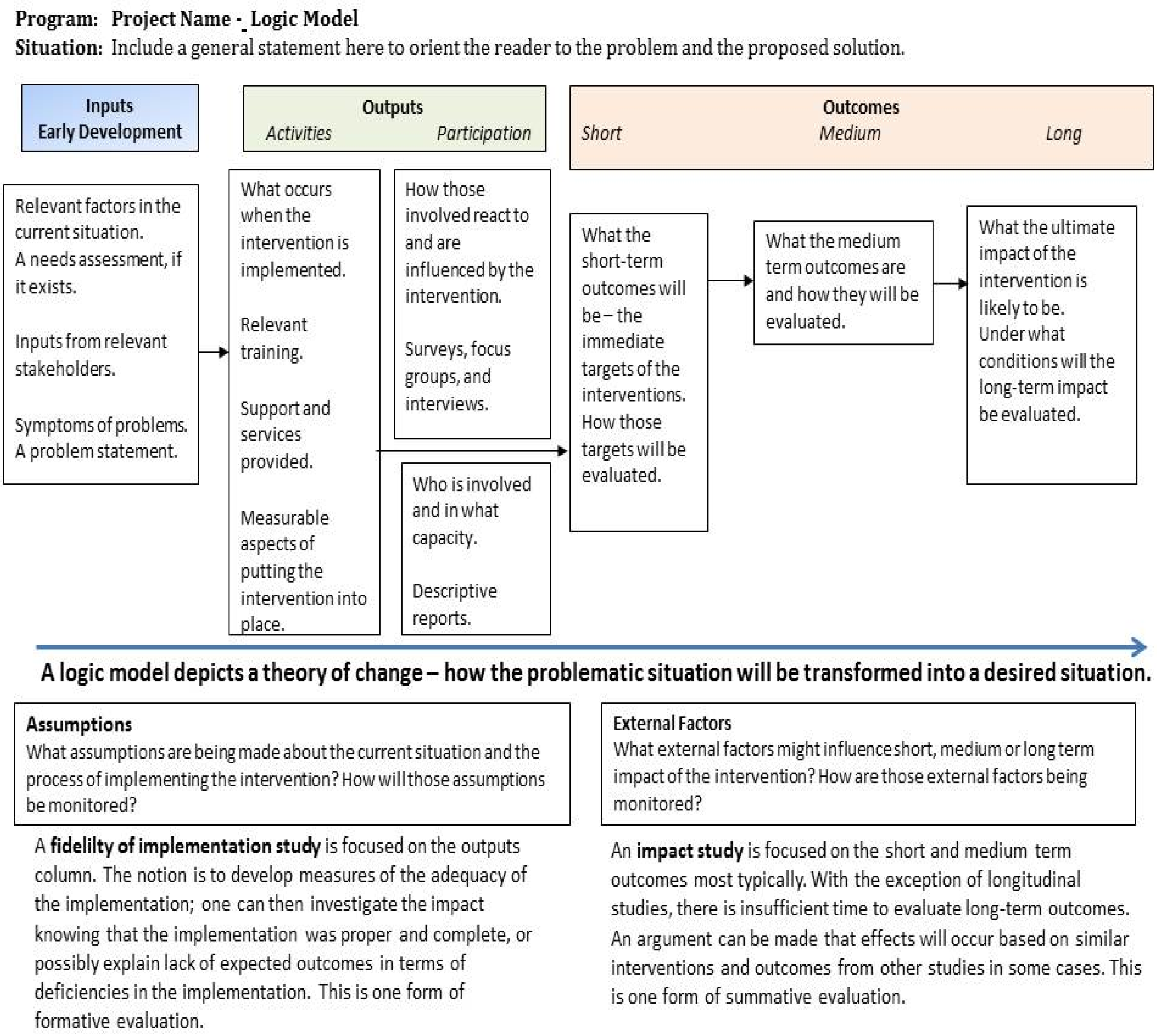

Figure 1. A generic logic model to guide evaluation and research.

Authentic learning tasks and dynamic, formative feedback are critical factors in supporting the effective integration of technology in learning and instruction. Other challenges in research and development pertaining to educational technology include making game-based learning more than a motivational exercise, refining and deploying methods to capture how someone is conceptualizing a complex problem, modeling individual learner progress, and using data mining and learning analytics to personalize learning.

CONCLUDING REMARKS

What is technology? This is not a test – it is a reminder. Technology is the purposeful application of knowledge to benefit society or a group of people. Technology is supposed to be used to support the common good. Sometimes that does not happen. As educational technologists, this is a reminder that the purpose of educational technology is not to promote an individual's career or reputation nor to benefit a particular company but, rather, to improve learning. Like any other technology or tool, an educational technology can be misused. Because technologies change and are changing so rapidly, it is important to be cautious with regard to large-scale implementations of an educational technology.

What is learning? Again, this is a simple reminder that learning is defined as a stable and persisting change in what a person or group of people know or can do. Learning is fundamentally about change – about useful and productive transformations. The task of instructional designers and educational technologists is to support and facilitate those changes and transformations. The implication is that proceeding on the basis of evidence rather than bias or preference is important.

What is teaching? During several talks at the University of Malaya and again at the IETC 2013 conference the definition provided for teaching was as follows: A teacher is the voice that encourages, the ear that listens, the eye that reflects the hand that guides, and face that does not turn away. Being a teacher is a tremendous responsibility. Basically the fundamental task of a teacher is to get students to have questions – not merely to ask questions but to *have* questions, to admit to not knowing or not understanding, to become bewildered, to want to know, to engage in a search for answers, to be open to alternative explanations, and to develop the skills needed to make progress in developing knowledge and understanding. Teaching is a serious enterprise that is seriously complex, yet it is a professional practice that is often undervalued and underappreciated.

In conclusion, one might ask this fundamental question: "What is likely to come from what I am doing today and planning to do in the future?" As O. K. Bouwsma wrote in an unpublished journal: "Surely your life will show what you think of yourself." Think of yourself as a servant – serving the public good – getting students to have questions – openly exploring the ways and means of using technology to improve knowledge and understanding of experience and the worlds in which we live.

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