CJLT RCAT
Canadian Journal of Learning and Technology
La Revue canadienne de l'apprentissage et de la technologie

Volume 40(3) Summer/été 2014

What is Educational Technology? An Inquiry into the Meaning, Use, and Reciprocity of Technology

Qu'est-ce que la technologie pédagogique ? Un examen de la signification, de l'utilisation et de la réciprocité de la technologie

Arun Lakhana, *Department of Education, Concordia University*

Abstract

This position paper explores the ambiguity of technology, toward refined understanding of Educational Technology. The purpose of education is described by John Dewey as growing, or habitual learning. Two philosophical conceptions of technology are reviewed. Dewey positions inquiry as a technology that creates knowledge. Val Dusek offers a "consensus definition," a systems approach to technology that merges into social construction theory and actor-network theory, both of which emphasize complex relations between humans and technology. Using Dewey and Dusek as reference, literature related to Educational Technology is reviewed. A history of its definitions and conceptions of hard (material) technology and of soft (process) technology are examined. Three brief case studies reveal a bias toward hard technology in contemporary discourse. A misconception that soft technology begins with pre-authenticated knowledge is identified and shown to obscure the reciprocity between technology and the intellect.

Key words: educational technology, inquiry, technological systems approach, technology, tolerance of ambiguity

Résumé

Cet exposé de position se penche sur l'ambiguïté de la technologie en vue de raffiner la compréhension de la technologie pédagogique. L'objectif de l'éducation est décrit par John Dewey comme étant un apprentissage croissant ou habituel. Deux conceptions philosophiques de la technologie sont examinées. Dewey considère l'enquête comme une technologie qui crée le savoir. Val Dusek offre une « définition consensuelle », une approche systémique de la technologie qui rejoint la théorie de la construction sociale et la théorie de l'acteur-réseau, qui mettent toutes deux l'accent sur les relations complexes entre les humains et la technologie. Utilisant Dewey et Dusek comme référence, la documentation portant sur la technologie pédagogique est examinée. L'historique des définitions et conceptions de la technologie « dure » (matérielle) et de la technologie « douce » (processus) est examiné. Trois courtes études de cas révèlent un parti pris pour la technologie dure dans le discours contemporain. Une fausse idée voulant que la technologie douce commence par un savoir préauthentifié est cernée, et il est démontré qu'elle cache la réciprocité entre la technologie et l'intellect.

Mots clés : technologie pédagogique, enquête, approche technologique systémique, technologie, tolérance de l'ambiguïté

Introduction

The purpose of this position paper is to explore the ambiguity of the "Educational Technology" (ET) concept, specifically, the meaning of the word "technology." At its simplest, ET appears to pertain to the application of mechanical and material tools (especially, computers and computer programs) to problems in education. A more complex conception of ET includes immaterial tools, such as processes and ways of thinking, and it addresses the causal interdependence between intellectual growth and technological growth, whereby technology is not merely processes and tools, but is understood systemically.

In part one of this paper, I offer a functional meaning of the term "education." John Dewey (1916/1944) provides a comprehensive and versatile description: the ultimate end of education is habitual learning, characterized as intellectual growing (p. 53). For Dewey, knowledge is continuously and interactively transformed, learning takes place in experience, and ideas are understood as temporal, not final. In part two of this paper, I consider two complex conceptions of technology. In Dewey's theory, productive inquiry can be understood as a technology that produces and transforms knowledge, which challenges the apparent ontological superiority of intellect over technology. Val Dusek (2006) claims that the "consensus" definition of technology is characterized by a systems approach, as opposed to a tools or a rules approach. Dusek's definition implicates human and non-human actors and emphasizes relationships. In part three, with Dewey and Dusek serving as reference, I review literature related to ET. I begin with a brief history of the field, including its evolving definitions as provided by the Association for Educational Communications and Technology (AECT). The AECT distinguishes between *hard* and *soft* technology. Conceptually, hard technology identifies mainly with computers and material tools. Soft technology includes immaterial resources, such as processes and rules. With three brief cases studies of contemporary academic and political discourse related to ET, I find a bias of attention on hard technology. Furthermore, I detect a lack of impact of Dewey's insistence on the continuous reconstruction of knowledge through technology and of Dusek's insistence on the complex relations between various actors within a system. I conclude with thoughts about contemporary interpretations of ET.

My goal is to use Dewey and Dusek to critically evaluate existing theories of ET. The main issues that I consider are: (a) limited interpretations that restrict ET to applications of hard technology and (b) a misconception that technology always begins with pre-authenticated knowledge, which de-emphasizes the situation of the human in the system and the reciprocity between technology and the intellect. I advocate sensitivity to broad interpretations of technology. Working with its ambiguity potentially invigorates ET theory, dispels myths that limit ET to matters of hardware, challenges the concept of pre-authenticated knowledge, and demystifies human-technology co-evolution.

Education and Growing

I choose Dewey's theory of education because it is comprehensive and generalizable. Dewey's theories share similarities with many other philosophers' theories. For example, Jerome Bruner emphasizes experience in the construction and reconstruction of a learner's world; Paolo Friere dismisses the "banking" concept in education, wherein facts are deposited into the learner; and Lev Vygotsky insists that practical activity directly contributes to learning and development. Likewise, Dewey had concerns about experience, facticity, and activity. In the following paragraphs, I briefly explain his position on growth and its relationships with habitual adaptation to experience, evolution of knowledge, and the act of inquiry.

Dewey (1938/1997) writes, "The educative process can be identified with growth when that is understood in terms of the active participle, growing" (p. 36). In general, growing means continuous physical and intellectual evolution and adaptation. Continuity implies that deliberate, intellectual operations emerge from organic activities, "without being identical with that from which they emerge" (p. 19). The intellect grows out of biology: our earliest habits are biological; we use our organs and appendages for inquiry. However, the environment in which humans live is both biological and cultural. While biological growth has concrete consequences, intellectual growth allows for the symbolic representation and rehearsal of consequences, which gives experience another dimension: the ability to learn and to pass customs and traditions across generations. Thus a society reproduces itself, which leads us to the purpose of education.

Education cultivates a habit to learn. To be clear, Dewey (1916/1944) differentiates between two aspects of habit. *Habituation* refers to "a general and persistent balance of organic activities with the surroundings," while *habitual adaptation* refers to the plasticity of an organism, its "active capacities to readjust activity to meet new conditions … The former furnishes the background of growth; the latter constitutes growing" (p. 52). As an example, "for the child to realize his own impulse by recognizing the facts, materials, and conditions involved, and then to regulate his impulse through that recognition, is educative" (Dewey, 1956/1990, p. 40). Capacities to readjust activities deliberately in order to develop future experiences may appear to be teleological, yet not in the popular sense of reaching for final ends, but in the sense of searching for and testing "ends-in-view," *ideas* about the future. Learning reflects this ongoing, purposeful evolution of knowledge.

Echoing Darwin's theory of evolution, Dewey (1910) preferred examining change rather than permanence. He preferred "treating the forms that had been regarded as types of fixity and perfection as originating and passing away" (p. 1). For Dewey, education is not about conveying a fixed set of ideas, recipes, or tools. Knowledge is not intrinsic, not discovered, not absolute. Rather, knowledge is applied, tested, and subject to transformation. To create a capacity for knowledge, the security that one seeks in final certainty must be transformed "from inert dependence upon the past to intentional construction of a future" (Dewey, 1929, p. 290). With inquiry serving as a means, learning becomes an end in itself.

Dewey (1930/1999) championed inquiry because "a program of ends and ideals if kept apart from sensitive and flexible method becomes an encumbrance" (p. 82). While ideas, recipes, and tools do serve a purpose (warranted by situations), Dewey's instrumental philosophy emphasizes acquisition and exercise of ideas above ideas themselves. Rather than dislocate ideas from practice, Dewey stresses the continuity and interactivity of experience. He sees ideas as instruments of discovery both for individuals and for society at large. Pragmatically, what an idea *does* constitutes its meaning. Ideas thus function as malleable tools of inquiry – ends and means – for the development of further logical and ethical ideals. In effect, knowledge is practically organized for the liberation of human intelligence. Inquiry challenges intellectual and cultural limits, ad infinitum.

Conceptions of Technology

In this section, I introduce the AECT's conception of technology, then, I examine two philosophical conceptions of technology. Primarily, I turn attention back to Dewey. His insistence on the inseparability of means and ends lead to a discussion of inquiry as a technology that produces knowledge. Secondarily, I review Dusek's theory of technology. Dusek provides a consensus definition of technology that treats technology systemically. It is his position that technology is constructed within a relational network of many types of actors.

The AECT, in their 2008 definition of ET, includes both hard technology and soft technology. Specifically, by soft technology, the AECT means "intellectual processes" – transformative methods or actions that facilitate learning and performance (Januszewski & Molenda, 2008, p. 196). As an intellectual process, technology is thought to mediate between inputs and outputs (see Figure 1). By focusing on "human made processes that systematically apply scientific knowledge," the AECT intentionally neglects "nontechnical processes, such as cognitive processes, biological processes, and spiritual processes" (p. 197). The AECT's demarcation between "technical" and "nontechnical" processes is interesting. It attempts to delineate which processes belong in the field of ET and which do not. However, this demarcation appears subjective; the boundary between processes that are intellectually intentional and those that are not can be blurry. That the intellect must inform technology presupposes the existence of a pre-authenticated intellect. One might ask: Where does the intellect come from? Dewey and Dusek suggest that not only does the intellect give rise to technology but that technology also gives rise to the intellect.

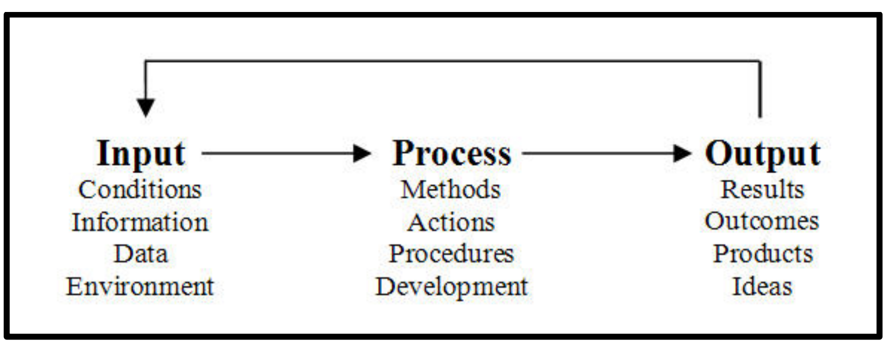

Figure 1. The AECT's Input – Process – Output paradigm. Adapted from *Educational Technology: A Definition With Commentary* by A. Januszewski and M. Molenda, 2008, p. 196.

The AECT's demarcation of "technical" versus "nontechnical" processes can be challenged. Dusek suggests that technological processes exist in a system that includes but is not necessarily dominated by the intellect. This approach places humans, organizations, skills, and tools within complex systems. Dusek also evaluates the neutrality of technology, and he points out the inextricable feedback between technology and society, which can be disproportionate in either direction. For Dewey, technology includes inquiry – an interactive, experiential process that habituates intellectual adaptation. Here, prioritizing intellect ahead of technology is illusory: knowledge itself is understood as a technological artefact.

Dewey's Conceptualization of Inquiry as Technology

Dewey (1938) defined inquiry as "the directed or controlled transformation of an indeterminate situation into a determinately unified one" (p. 117). Inquiry, or questioning, provides interactive recourse to situational dissonance. Productive inquiry adjusts prior experiences to future experience. It yields resolution: warranted assertions. These assertions act as regulative tools. Dewey's emphasis on the interactive nature of tools provides relief against the view of tools (including knowledge) as separate and objective artefacts; his emphasis on the continuity of experience provides contrast to the idea of discrete moments, which, aside from their sequence, may appear disjointed. Dewey instead suggests that tools are carried *into* the continuity of experience and transformed through controlled inquiry. Knowledge itself, including conceptual definitions, can be seen as a tool that comes alive through the process of inquiry. Furthermore, the process of inquiry can be understood as technological in that it utilizes, activates, and refashions prior knowledge.

Unlike habituation, whose blind allegiance to impulse rigidly assumes one situation to be essentially the same as the next, Dewey's (1916/1944) principle of knowledge rests on the freedom of prior experience to be subject to, and informed by, new experience. According to Dewey (1956/1990), experience is educative to the extent that an individual can realize his or her impulses by recognizing the conditions involved, and then regulate those impulses intentionally through that recognition. For example, a mechanic who understands a machine only by virtue of habitual repairs will find himself lost when an unexpected situation arises, whereas a mechanic who understands the machine "knows the conditions under which a given habit works, and is in a position to introduce changes which will readapt it to new conditions" (Dewey, 1916/1944, p. 340). This general pattern of productive inquiry – goal-oriented thinking and regulated action, where theory and practice merge – is "in its robust sense" a technology (Hickman, 2001, p. 181). The process of inquiry utilizes and produces material and immaterial technological artefacts (including knowledge), and the artefacts themselves can be viewed as technologies (recursively emerging). Critically, this general pattern applies to all types of inquiry, "cases that involve what we would call hardware, and it also fits cases that are patently conceptual … it applies to logical and mathematical proofs, and it applies in social and political inquiry" (p. 33).

Knowledge clearly enters into the process of inquiry. Yet knowledge is also a product of inquiry – a technological artefact. By placing knowledge in both positions, as input and as output, knowledge ceases to be stuck in the position of an *a priori* (before experience) object of reflection. Knowledge, evolved, can be conceived as an *a posteriori* (after experience) result of reflection. Based on this appraisal, science could not be ontologically superior to technology: the tool of inquiry creates knowledge, as opposed to a unilateral view that knowledge creates the tool (Hickman, 2001, p. 10).

Dewey (1916/1944) questions the precedence of science to technology. He favours continuity over discrete dualisms, deploring the false dichotomy of ends versus means (p. 333). While acknowledging that abstract intellectualism promotes clarity, consistency, and much-needed relief from superstition, he also writes of its “formal and empty nature”: “bare logic, however important in arranging and criticizing existing subject matter, cannot spin new subject matter out of itself” (p. 299). Inquiry is deemed technological precisely when it regulates the ongoing *development* of knowledge. This learning process, Dewey says, is based in continuous and interactive experience. Reducing the educative wealth of experience to a formal process of applied intellect, as the AECT definition might imply, could promulgate an unfortunate illusion. Ambiguously, the intellect must also be viewed as a product.

Dusek’s Systems Approach as a “Consensus” Definition

Dusek (2006) examines various definitions of technology. He suggests a systems approach as the “consensus” definition of technology. According to Dusek, the consensus definition is “the application of scientific or other knowledge to practical tasks by ordered systems that involve people and organizations, productive skills, living things, and machines.” (p. 35). Dusek distinguishes this conception, which combines both hard and soft technologies, from other definitions of technology, as hardware or as rules. He says that the hardware definition is most obvious – tools are literally graspable – and this “lies behind much discussion of technology even when not made explicit” (p. 31). For example, technology is routinely symbolized by icons such as rockets, factories, microscopes, and computers. However, this “hard” definition of technology fails when one claims that a technology does not use either tools or machines, such as Dewey’s inquiry and the psychologist B. F. Skinner’s behaviour technology, conditioning. The definition of technology as rules refers to “patterns of means-end relationships,” or goal-directed methods (p. 32). This approach better accommodates Dewey’s and Skinner’s theories. However, it must be noted that, for Dewey especially, “ends do justify the means, but not every end is sufficient to justify its means. Ends and means must be fitted to one another” (p. 58). In the systems approach, technology can be understood to have “a life of its own” (p. 36).

According to Dusek (2006), “Advocates of the technological systems approach have recently begun to ally with or even fuse with the social construction of technology approach” (p. 36). Social construction of technology implies that technological artefacts, including inventions, devices, and concepts, are made and remade not by individuals but by people working together. The construction involves current and historical social context, power relations, and systems of meaning. In this analysis, technology means different things to different people, humans and technology are deeply interrelated, and technology ceases to be understood as neutral. “The technological system cannot be neatly separated off from the rest of society or nature” (p. 208).

Closely related to the social construction approach is actor-network theory (ANT). According to Latour (2005), ANT is a theory “about how to study things, or rather how not to study them – or rather, how to let the actors have some room to express themselves” (p. 142). The actors, or participating agents in the network, may be human or non-human, living or inanimate. The main thrust of ANT is that relationships must be examined. ANT denies any division between social and material worlds; it does not privilege the human. The main criterion for the inclusion of things to be examined within the system is that the things (human or not) *do* something. “If they make no difference, drop them, start the description anew. You want a science in which there is no object” (p. 154). In other words, ANT wants to relinquish attention from symbols and objects, and focus instead on the role of the thing in relation to the rest of the system. ANT is not exactly an easy theory, because it requires us to rethink the world, including: our belief in an essential nature of things; our habitual separation of sociology from technology; and our de-emphasis on non-human agents in the system. It is akin to Dewey's emphasis on change. What effect a thing has (and will have), as opposed to what a thing is, is significant.

How might these insights inform ET? In the following section, I will examine what educational technologists propose is the meaning of technology and I will compare and contrast popular definitions with Dewey's and Dusek's theories. We will find that there are voices actively promoting soft technology and a systems approach; however, there is also a dominant voice that holds that technology exists materially and objectively, separable from its social relations.

Educational Technology – Literature Review

"Technology" refers to applications, methods, theories, and practices that are used to reach desirable ends, especially industrial and commercial ends (*The American Heritage Dictionary*, 2009; *Collins Dictionary*, 2003; *Random House Kernerman Webster's College Dictionary*, 2010). I refer to this type of dictionary definition as inclusive of *soft technology*, which the AECT defines as "human made processes that systematically apply scientific knowledge" (Januszewski & Molenda, 2008, p. 197). This soft conception approaches but may not meet either Dewey's theory of inquiry, which is explicitly interactive and continuous, or Dusek's technological systems approach, which emphasizes networks of relationships. More commonly, technology suggests a subordinate entry in the dictionary: "electronic or digital products and systems considered as a group" (*The American Heritage Dictionary,* 2009). This popular conception of the equivalence between technology and electronic tools greatly diminishes the scope of technology: it ignores methods, theories, and practices; it downplays technological-social relations; and it focuses mainly on computers. I refer to this exclusive conception of technology as *hard technology*. This hard conception sharply contrasts with Dewey's and Dusek's conceptions.

In my review of literature related to ET, I find a common divide between proponents of hard technology and proponents of soft technology. The first part of this review provides background with a brief history of ET, including evolving AECT definitions. I find that those who have worked over the years to define ET often write in favour of recognizing the relevance of soft technology. Despite their efforts, I find bias toward hard technology within contemporary ET research and literature. In the second part of the review, I present this bias, discernible through three brief cases studies: an analysis of two recent U.S. government publications related to national ET implementation; a search across current peer-reviewed journal articles indexed under the ET keyword in the Education Resources Information Center (ERIC); and an appraisal of "technology knowledge" within the popular Technological Pedagogical Content Knowledge (TPACK) framework. Next, in the third part, I review more generalized conceptions of technology. While broader interpretations represent an improved recognition of the potential of technology in education, some soft technology conceptions still limit our understanding of the term because they prioritize intellectual knowledge over technology, thereby deemphasizing the role of technology in the cultivation of the intellect, in contrast to Dewey's inquiry as technology. I offer explanations for the existence of these biases in the conclusion of this paper.

A Brief History of Educational Technology and its Evolving Definitions

According to Alan Januszewski (2001), former chair of the Definition and Terminology Committee (DTC) for the oldest professional and academic association related to ET, the AECT, ET has invested more time and energy trying to define itself than any other field. Januszewski and Molenda (2008) suggest two primary reasons for this investment: practitioners' desire to stake out a professional niche and desire for legitimization through "certainty in the meaning and use of terminology in our field" (p. 348). By the strictest of standards, Januszewski (2001) acknowledges that no dictionary definition meets its formal criteria, that is, the inclusion of everything that belongs in its description and the exclusion of everything else. Luppicini (2001) and Januszewski agree that the creation of an authoritative ET definition appears to be a political act. Definitions are not value-neutral. Definitions are socially constructed, reflecting choices and circumstances.

Theories of ET emerged early in the twentieth century, alongside improvements in industrial efficiency, developments in audiovisual equipment, and growing interest in instructional psychologies (Januszewski, 2001; Luppicini, 2007). The application of science to education was viewed from at least three different perspectives: some chose to agree with G. Stanley Hall that curriculum research should occur in natural environments to better align with children's natural behaviour; some followed Dewey, modelling science as an active process of reflective inquiry; and some adopted a scientific approach primarily as a means for precise standards and measurements (Januszewski, 2001).

James Finn, an early proponent for a professional field of ET, advocates a systems approach to instructional problems (Beckwith, 1988; Luppicini, 2008; Reiser & Ely, 1997). Finn (1962) echoes Dewey's sentiment that "ends and means are inseparable … ends become means to further ends" (p. 32). This thesis of inseparable ends and means can be bewildering. For example, Januszewski (2001) questions Finn's non-intuitive description of "automation": Finn ambiguously suggests that automation *is* technology and also *includes* technology. The idea that technology (i.e., automation) includes itself (i.e., other technology) requires contemplation through a systems approach. Finn describes "automation in education" not as "a manless, machine-operated production," but instead as a systemic "way of thinking involving patterns and self-regulation" as well as containing further technologies, such as "long-range planning" and "wise decision-making" (Januszewski, 2001, p. 23). In other words, technology, as an apparent end, can be recast as an apparent means within a broader technology. Recall Dewey's distinction between habituation and habitual adaptation: automation, interpreted weakly, suggests habituation (learned repetition); in contrast, Finn's strong interpretation of automation suggests habitual adaptation, which involves the recognition of impulses and conditions (here: recognition = ends) and regulation through that recognition (here: recognition = means).

Finn's emphases on processes and systems theory influenced the first formal definition of the field, which was attributed not to ET but to "Audiovisual Communications" (under the auspices of the Department of Audiovisual Instruction, DAVI). The *1963 DAVI definition* reads: "Audiovisual communication is that branch of educational theory and practice concerned primarily with the design and use of messages which control the learning process" (Ely, 1963, p. 18, as cited in Reiser & Ely, 1997, p. 65). The next definition referred explicitly to ET as the AECT came to replace DAVI in 1970. Here is an excerpt of the *1972 AECT definition of ET*: "Educational technology is a field involved in the facilitation of human learning through the systematic identification, development, organization and utilization of a full range of learning resources and through the management of these processes" (Ely, 1972, p. 36, as cited in Reiser & Ely, 1997, p. 67). The full definition includes several themes: human-centred instruction (as opposed to controlled), a continued emphasis on a systems approach, and a greater emphasis on physical resources in comparison to processes-as-resources (Januszewski, 2001, p. 67). According to Januszewski and Molenda (2008), this de-emphasis on processes – a setback for the profession – was motivated by the 1970 Presidential Commission on Instructional Technology, which primarily attended to the role of media in instruction.

The *1977 AECT definition of ET* reads in part: "Educational technology is a complex, integrated process, involving people, procedures, ideas, devices and organization … involved in all aspects of human learning" (AECT, 1977, p.1, as cited in Reiser & Ely, 1997, p. 68). Januszewski and Molenda (2008) suggest that, by re-emphasizing processes, the authors of the new definition reacted against the 1970 Presidential report. The new definition suggests that ET itself is a process that includes other performance technologies (i.e., procedures, ideas, organization); and, by infusing the definition with systems concepts, the authors imply that the use of systems concepts is also a process. The complexity of the 1977 definition and the perceived need to stake out professional territory led to a focus on simplification. The *1994 AECT definition* reads: "Instructional technology is the theory and practice of design, development, utilization, management, and evaluation of processes and resources for learning" (Seels & Richey, 1994, p. 1, as cited in Reiser & Ely, 1997, p. 68). Here, the authors switch labels from ET to Instructional Technology, which, while synonymous with ET, appears to be more precise, emphasizes learning with instruction (as opposed to incidental learning), and implies more settings for practice. This definition includes an explicit focus on soft technology, including techniques and strategies.

In their most recent definition, the AECT has reverted to the ET label and continues to stress soft technology. Less is said of the social construction of technology and of ANT. The *2008 AECT definition of ET* reads: "Educational Technology is the study and ethical practice of facilitating learning and improving performance by creating, using and managing appropriate technological processes and resources" (Januszewski & Molenda, 2008, p. 1). Januszewski and Molenda (2008) acknowledge that other definitions and conceptions of ET exist beyond the AECT definitions, that the current AECT definition is only a "snapshot" in time, and that "when looked at from this perspective, when it comes to educational technology, we may never really know what we are talking about" (p. 349). Current chair of the DCT, Nancy Hastings, says that the AECT is beginning work on a new definition, but she "[does] not expect to see a new definition until at least 2017-18" (personal correspondence, May 27, 2014).

The evolving definitions of ET reflect a history of social change, different definitions reflecting different generations. In their commentary on the evolution of ET definitions, Reiser and Ely (1997) suggest that "continuing attempts to redefine the field are good signs; signs that as new ideas, techniques and devices come along, professionals in our field will re-examine their activities and, in some cases, adjust their efforts and their view of the profession" (p. 71). They propose that existing definitions, including those provided by the AECT, are starting points for dialogue, not end points. Lowenthal and Wilson (2010) agree with Ely that the ET definition should continue to grow through dialogue. Silber applauds the AECT's continuing efforts "to use the correct definition of the word 'technology,' and to de-emphasize the 'stuff' of our field as the raison-d'etre of the field" (Richey, Silber & Ely, 2008, p. 24). In their response to the 2008 definition, Hlynka and Jacobsen (2009) concur with the AECT's "sharp focus on facilitating learning and improving performance via technological processes and resources, versus products or tools" (para. 14). They, like Dusek, lament the fact that "most often, the concepts default into issues of hardware, tools and things" (para. 1).

Conceptions of Educational Technology in Terms of Hard Technology

Despite the efforts of the AECT, shallow conceptions of technology prevail in contemporary academic and political ET literature. I provide three brief cases. First, in two recent U.S. government publications, all references to technology refer to hard technology. This is alarming, considering how professional associations such as the AECT have historically struggled against governmental discourse (see, for example, the 1972 and 1977 AECT definitions of ET). Second, a search related to ET within peer-reviewed articles listed in ERIC reveals a bias toward hard technology interpretations in academic research. When speaking of technology, researchers routinely mean computer systems. Third, I investigate TPACK, a framework for integrating technology into classrooms. This approach equates knowledge of technology with knowledge of hard technology. In each of these cases, I detect a neglect of softer conceptions of technology, including Dewey's process of inquiry and Dusek's technological systems approach.

U.S. government publications. The 2010 document, *Transforming American education: Learning powered by technology* (U.S. Department of Education's Office of Educational Technology), contains hundreds of references to technology, each of which conflates technology with computer tools. For example, the authors write that outside of school, students' lives are "filled with technology" that enables "mobile access to information and resources 24/7," the creation of "multimedia content," and participation in "online social networks and communities"; furthermore, "technology dominates the workplaces of most professionals and managers in business" including physicians' use of "mobile Internet access devices to download x-rays and test results," geologists' use of "underground sensors along fault lines," and filmmakers' use of "everyday computers and affordable software for every phase of the filmmaking process" (p. 9). In a graphic illustrating "a model of learning, powered by technology," the icon for technology is a laptop computer (predictably), which connects the student to online networks of ideas (p. 11). Curiously, ideas themselves are not recognized as technology.

A similar conception of technology is evident in a document entitled *Educational technology in U.S. public schools: Fall 2008* (National Center for Education Statistics, 2010). This document contains results from "district, school, and teacher surveys on educational technology," which reveal "data on availability and use for a range of educational technology resources, such as district and school networks, computers, devices that enhance the capabilities of computers for instruction, and computer software" (p. 1). No mention is made to technological resources such as methods, theories, or practices. In fact, the authors provide the following succinct definition of technology:

> Technology: Information technology such as computers, devices that can be attached to computers (e.g., LCD projector, interactive whiteboard, digital camera), networks (e.g., Internet, local networks), and computer software. We specifically are not including non-computer technologies such as overhead projectors and VCRs. (p. B-11)

The fact that the U.S. Office of Educational Technology and the U.S. Department of Education refer to "educational technology" exclusively in relation to computers suggests that we need to review national conceptions of ET.

ERIC references. Bias amongst scholars toward hard interpretations of technology is evident in ERIC. I sampled 199 peer-reviewed journal articles published in 2012 and indexed under the ERIC thesaurus descriptor, “educational technology” (see Appendix A). I limited my analysis to a cursory search across abstracts and additional descriptors for these articles. I neglect the nuanced research efforts of these authors (I imagine that all of them implicitly or explicitly attend to the dynamic complexity of learning processes). My interest here specifically relates to their use of the term, technology. My question is: what does each researcher mean by the term, technology? Of 199 articles, I found that 166 (83%) appear to use the term in reference to the use, management, or creation of hard technology, mainly computer systems. The output of ET research underrepresents soft technology and does not appear to approach Dusek’s “consensus” definition.

TPACK conception of technology. The TPACK framework provides teachers with supplemental “pedagogical knowledge” in order to augment “technology knowledge” (e.g., Harris & Hoffer, 2011). According to one of its authors: “Technology knowledge is knowledge about standard technologies such as books and chalk and blackboard, as well as more advanced technologies such as the Internet and digital video. This would involve the skills required to operate particular technologies” (Koehler, 2011, para. 1). In this framework, technological knowledge requires supplemental pedagogical knowledge because knowledge of technology refers exclusively to knowledge of hard technologies (including the skills by which hard technologies are used). This contrasts with the AECT’s view that knowledge of technology refers both to knowledge of hard technology and to knowledge of soft technology (including the skills by which both hard and soft technologies are used). In the TPACK approach, soft conceptions of technology are ignored.

Conceptions of Soft Technology and a Systems Approach

Soft technology refers broadly to immaterial resources, which can include processes, practices, and theories. Early leaders in the field stressed that “technology is not, as many of the technically illiterate seem to think, a collection of gadgets, of hardware, of instrumentation,” rather “technology is, fundamentally, a way of thinking” (Finn, 1962, pp. 29/33). Many endorse this conception, including Dewey, Dusek, and Concordia University’s Department of Education, who write in their ET Master of Arts program booklet, “Educational technology is a rapidly growing field that generally refers to the application of processes and styles of thinking developed outside the field of education to solving educational problems” (2008, p. 1). Despite endorsements, advocates agree that soft conceptions of ET are commonly misunderstood or ignored (e.g., Finn, 1962; Hlynka & Jacobsen, 2009; Januszewski, 2001; Januszewski & Molenda, 2008; Luppicini, 2005; Richey, Silber & Ely, 2008). For example, Luppicini (2005) writes that defining ET as a process “creates dissonance between the popular notion of technology as state-of-the-art equipment and the older idea of technology as a process … [which] gives rise to definitions that are not easily understood within the field or widely embraced outside” (p. 105).

The AECT conscientiously embraces both hard technology and soft technology. As soft technology, the AECT specifies “intellectual processes” – “human made processes that systematically apply scientific knowledge” (Januszewski & Molenda, 2008, p. 197). It emphasizes an intellectual foundation for technology, which opposes Dewey’s view of the interactive nature of experience. Some argue that ET is preceded not only by scientific knowledge but also by literature and the arts (Luppicini, 2005; Solomon, 2000). Some wonder, like Dewey, how a technology that is "pre-authenticated" by the intellect faithfully predetermines correspondence between tasks in a learning environment and tasks in a learner's real world, a "world that is constantly being shaped and reshaped by learners working within their own experiences" (Petraglia, 1998, p. 60). Luppicini (2005) suggests as key themes in ET: adaptive, systematic, and transformative processes that facilitate human needs, as well as mental, environmental, and social influences (p. 105). Finn (1962) writes, "technology in society is an organic process" (p. 32). In an attempt to find the right words, Finn quotes Hannah Arendt who in turn quotes Werner Heisenberg: "general technology is no longer 'the product of a conscious human effort to enlarge material power, but rather like a biological development of mankind'" (p. 32). These authors cross paths with Dusek's technological systems approach and their interpretations extend the concept of educational technology to include processes that are intellectually designed as well as some that might not be.

Conclusion

The ET profession, field, and concept benefit from a broad appreciation of soft technology and of the technological systems approach. Human intellect plays a central role in the cultivation of technology and of knowledge, but it is not alone. Experiential and social processes can be seen to inform the technologies and ideas we create. Technology itself can be understood to influence our intellectual, experiential, and cultural capacities for creation. An ontological superiority of knowledge over technology is illusory. Our ideas, tools, and processes can both limit and liberate our next thought.

So why do limited interpretations of technology dominate? "If educational technology is a process, as the majority of the members of the AECT view it, then why does most of the history that is written about it focus on the hardware and equipment that is used in the field?" (Januszewski, 2001, p. xxiii). This dominant discourse emerges from multiple causes. First, Januszewski describes a desire for conceptual and professional legitimization of ET through an emphasis on "objectivity, permanence, and exact standards," which bluntly opposes Dewey's emphasis on inquiry, regulation, and habitual adaptation (p. 115). Objectivity, permanence, and exactitude insinuate the realm of the physical sciences, not the social sciences. This leads to a second reason. The desirable resemblance to physical sciences brings to mind material reality, which may reinforce hard/material conceptions and obscure alternate conceptions. As Dusek reminds us, physical things are simply easier to conceptualize, easier to grasp; immaterial resources can be tricky to grasp. Likewise, the idea that an *idea* is a technology – a generative and regulative tool that produces ideas – is unintuitive. This meta-idea challenges the assumption that knowledge ontologically precedes technology; it admits that knowledge might be contingent on technology. A third reason is that publications disseminated by governmental, academic, and professional authorities substantiate an equation of ET with the use of computers and other material tools. Practitioners must struggle against this hegemony.

While I commend their efforts to raise awareness, why does the AECT limit their current definition of soft technology to: "human-made processes that systematically apply scientific knowledge" (Januszewski & Molenda, 2008, p. 197)? The AECT's distinction between intellectual and non-intellectual processes provides their audience with several benefits: a sense of clarity about the scope of the ET field, a desirable aura of scientific legitimacy for the ET profession, and an avoidance of esoteric complexities in ET theory. I look at each of these in turn.

The AECT's definition of intellectual processes clarifies that processes within ET purview must be flexible and open, for example, capable of managing uncertainty. However, by dismissing non-intellectual processes as out-of-scope, the AECT exaggerates the importance of intellectual intention and neglects the effect of other actors on the intellect. They fail to address substantially the systemic interaction between non-intellectual processes and intellectual ones. Yet, as we have seen through Dewey and Dusek, the boundary between intellect and non-intellect is blurry, the actors interrelate, and the relationship deserves primary attention. A dualistic demarcation reflects an artificial convenience. Such a figurative dissociation deserves serious contemplation within an ET manifesto, lest it be interpreted as reality, spreading an illusion of clarity.

By circumscribing what is and is not in the purview of ET practice, the AECT attempts to legitimize the profession and claim territory. Furthermore, the story about "a systematic application of scientific knowledge" is appealing: the use of science lends a sense of control and an aura of authority to the ET professional. However, unlike the field of physics, social science lacks reliable paradigms and "History suggests that the road to a firm research consensus is extraordinarily arduous" (Kuhn, 1970, p. 15). The validity of claims in social science depends on many factors, including culturally based opinions and customs. When reconsidered, these factors can reform the validation process itself.

Some final reasons why non-intellectual processes are under-emphasized is because they are complex: they do not reflect our intentions, they can feedback unpredictably, they operate on different time scales, and their ubiquity conceals them. Intuitively, we understand that natural processes can be the objects of scientific study; however, it is less intuitive to interpret them as actors. Upon critical analysis, we see that some non-intellectual processes do affect intellectual endeavours. For example, our form of culture affects our intellectual capacity and the type of science we do. The AECT's linear model, "input→process→output," is easy to digest (Januszewski & Molenda, 2008, p. 196). However, it fails to account for the hidden agentive potential for processes to transform their inputs, as in Dewey's theory. A more appropriate diagram might not only feedback on itself (connecting output back to input), but feedback also within itself: "input↔process↔output."

Ultimately and most generally, educational technologists aim to foster growth, that is intellectual development and habitual adaptation. Ideally, with the help of technology, we enable an ongoing ability to learn. To accomplish this effectively, we must consider the ambiguity of the concept – technology means far more than computers. Technology refers also to processes and may be understood best through a systems perspective. Technology is socially constructed. Technology affects the intellect that designs it. However, by defining ET broadly we do not finalize a semantic technicality. Conceptions are *technological*. As ends that serve as means, conceptions lead us into the future.

Authors' Note:

This article is based on the following master's thesis: Lakhana, A. (2012). Tolerance of ambiguity in educational technology: A review of two social science concepts (Master's thesis). Retrieved from http://spectrum.library.concordia.ca/975020

References

Beckwith, D. (1988). The future of educational technology. *Canadian Journal of Educational Communication*, *17*(1), 3–20. Retrieved from http://www.eric.ed.gov/ERICWebPortal/recordDetail?accno=EJ370727

Concordia University's Department of Education. (2008). *Educational technology program booklet*. Retrieved from http://doe.concordia.ca/documents/ETEC-HB-06182008.pdf

Dewey, J. (1910). *The influence of Darwin on philosophy*. New York: Henry Holt and Company.

Dewey, J. (1929). *The quest for certainty: A study of the relation of knowledge and action*. New York: Minton, Balch & Company.

Dewey, J. (1938). *Logic: The theory of inquiry.* New York: Henry Holt and company.

Dewey, J. (1944). *Democracy and education*. New York: The Free Press. (Original work published 1916)

Dewey, J. (1990). *The School and society / The child and the curriculum*. Chicago: The University of Chicago Press. (Original work published 1956)

Dewey, J. (1997). Experience and education. New York: Touchstone. (Original work published 1938)

Dewey, J. (1999). *Individualism old and new*. New York: Prometheus Books. (Original work published 1930)

Dusek, V. (2006). *Philosophy of technology: An introduction.* Massachusetts: Blackwell Publishing.

Finn, J. (1962). A John Dewey society paper: A walk on the altered side. *The Phi Delta Kappan*, *44*(1), 29–34. Retrieved from http://www.jstor.org/stable/10.2307/20342832

Harris, J., & Hofer, M. (2011). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional. *Journal of Research on Technology in Education*, *43*(3), 211–229. Retrieved from http://activitytypes.wmwikis.net/file/view/harrishofer-jrte-43-3-211-229.pdf

Hickman, L. (1990). *John Dewey's pragmatic technology*. Bloomingham, IN: Indiana University Press.

Hickman, L. (2001). *Philosophical tools for technological culture: Putting pragmatism to work*. Bloomingham, IN: Indiana University Press.

Hlynka, D. & Jacobsen, M. (2009). What is educational technology, anyway? A commentary on the new AECT definition of the field. *Canadian Journal of Learning and Technology, 35*(2). Retrieved from http://www.cjlt.ca/index.php/cjlt/article/view/527/260

Januszewski, A. (2001). *Educational technology: The development of a concept*. Englewood, CO: Libraries Unlimited Inc.

Januszewski, A., & Molenda, M. (2008). *Educational technology: A definition with commentary*. New York: Routeledge.

Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory.* Oxford: Oxford University Press.

Koehler, M. (2011). *Technology knowledge*. Retrieved from http://mkoehler.educ.msu.edu/tpack/technology-knowledge-tk

Kuhn, T. S. (1970). *The structure of scientific revolutions*. Chicago: The University of Chicago Press.

Lowenthal, P., & Wilson, B. (2010). Labels do matter! A critique of AECT's redefinition of the field. *TechTrends*, *54*(1), 38–46. Retrieved from http://www.springerlink.com/index/a40453437193u101.pdf

Luppicini, R. (2001). [Review of the book *Educational technology: A concept in development*]. *Educational Technology Research and Development*, *49*(3), 104–105. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/22915181

Luppicini, R. (2005). A systems definition of educational technology in society. *Educational Technology & Society*, *8*(3), 103–109. Retrieved from http://www.ifets.info/journals/8_3/10.pdf

Luppicini, R. (2007). *A study of how the academic field of educational technology has developed in Canada*. Unpublished doctoral dissertation, Concordia University, Montreal, Quebec, Canada.

Luppicini, R. (2008). Educational technology at a crossroads: Examining the development of the academic field in Canada. *Educational Technology & Society*, *11*(4), 281–296. Retrieved from http://www.ifets.info/journals/11_4/20.pdf

National Center for Education Statistics. (2010). *Educational technology in U.S. public schools: Fall 2008*. (NCES 2010–034). Washinngton: U.S. Government Printing Office. Retrieved from http://nces.ed.gov/pubs2010/2010034.pdf

Reiser, R., & Ely, D. (1997). The field of educational technology as reflected through its definitions. *Educational Technology Research and Development*, *45*(3), 63–72. doi:10.1007/BF02299730

Richey, R. C., Silber, K., & Ely, D. P. (2008). Reflections on the 2008 AECT definitions of the field. *TechTrends*, *52*(1), 24–25. doi:10.1007/s11528-008-0108-2

Solomon, D. L. (2000). Toward a post-modern agenda in instructional technology. *Educational Technology Research and Development*, *48*(4), 5–20. doi:10.1007/BF02300497

Technology. (2009). In *The American Heritage Dictionary of the English Language*. Retrieved from http://thefreedictionary.com/technology

Technology. (2003). In *Collins English Dictionary – Complete and Unabridged*. Retrieved from http://thefreedictionary.com/technology

Technology. (2010). In *Random House Kernerman Webster's College Dictionary*. Retrieved from http://thefreedictionary.com/technology

U.S. Department of Education, Office of Educational Technology (2010). *Transforming American education: Learning powered by technology.* Washington, DC. Retrieved from http://www.ed.gov/sites/default/files/netp2010.pdf

Appendix A: Technology Focus of Sample ET Articles

Table 1:
Technology Focus of Sample ERIC Articles Related to ET

	Article	Focus
1.	Lazonder, A. & Kamp, E. (2012). Bit by Bit or All at Once? Splitting up the Inquiry Task to Promote Children's Scientific Reasoning. *Learning and Instruction, 22*(6), 458 - 464. doi:10.1016/j.learninstruc.2012.05.005	S
2.	Wong, A., Leahy, W., Marcus, N. & Sweller, J. (2012). Cognitive Load Theory, the Transient Information Effect and E-Learning. *Learning and Instruction, 22*(6), 449 - 457. doi:10.1016/j.learninstruc.2012.05.004	S
3.	Ulusoy, K. (2012). A Study about Using Internet in History Lessons. *Educational Research and Reviews, 7*(4), 72 - 82.	H
4.	Ozturk, I. (2012). Wikipedia as a Teaching Tool for Technological Pedagogical Content Knowledge (TPCK) Development in Pre-Service History Teacher Education. *Educational Research and Reviews, 7*(7), 182 - 191.	H
5.	Sokolowski, A. (2012). Enhancing Interpretation of Natural Phenomena through a Mathematical Apparatus: A Proposal of an Interactive Unit in Optics. *International Journal for Mathematics Teaching and Learning*.	S
6.	Mainali, B. & Key, M. (2012). Using Dynamic Geometry Software GeoGebra in Developing Countries: A Case Study of Impressions of Mathematics Teachers in Nepal. *International Journal for Mathematics Teaching and Learning*.	H
7.	Hansen, N., Koudenburg, N., Hiersemann, R., Tellegen, P., Kocsev, M. & Postmes, T. (2012). Laptop Usage Affects Abstract Reasoning of Children in the Developing World. *Computers & Education, 59*(3), 989 - 1000. doi:10.1016/j.compedu.2012.04.013	H
8.	Biasutti, M. & EL-Deghaidy, H. (2012). Using Wiki in Teacher Education: Impact on Knowledge Management Processes and Student Satisfaction. *Computers & Education, 59*(3), 861 - 872.	H

doi:10.1016/j.compedu.2012.04.009

9. Chen, C. & Huang, T. (2012). Learning in a u-Museum: Developing a Context-Aware Ubiquitous Learning Environment. *Computers & Education, 59*(3), 873 - 883. doi:10.1016/j.compedu.2012.04.003 H

10. Desrochers, M. & Shelnutt, J. (2012). Effect of Answer Format and Review Method on College Students' Learning. *Computers & Education, 59*(3), 946 - 951. doi:10.1016/j.compedu.2012.04.002 S

11. Haelermans, C. & Blank, J. (2012). Is a Schools' Performance Related to Technical Change?--A Study on the Relationship between Innovations and Secondary School Productivity. *Computers & Education, 59*(3), 884 - 892. doi:10.1016/j.compedu.2012.03.027 S

12. Cheon, J., Lee, S., Crooks, S. & Song, J. (2012). An Investigation of Mobile Learning Readiness in Higher Education Based on the Theory of Planned Behavior. *Computers & Education, 59*(3), 1054 - 1064. doi:10.1016/j.compedu.2012.04.015 H

13. Corrigan, J. (2012). The Implementation of E-Tutoring in Secondary Schools: A Diffusion Study. *Computers & Education, 59*(3), 925 - 936. doi:10.1016/j.compedu.2012.03.013 H

14. Kolikant, Y. (2012). Using ICT for School Purposes: Is There a Student-School Disconnect?. *Computers & Education, 59*(3), 907 - 914. doi:10.1016/j.compedu.2012.04.012 H

15. Rienties, B., Giesbers, B., Tempelaar, D., Lygo-Baker, S., Segers, M. & Gijselaers, W. (2012). The Role of Scaffolding and Motivation in CSCL. *Computers & Education, 59*(3), 893 - 906. doi:10.1016/j.compedu.2012.04.010 S

16. Ng, W. (2012). Can We Teach Digital Natives Digital Literacy?. *Computers & Education, 59*(3), 1065 - 1078. doi:10.1016/j.compedu.2012.04.016 H

17. Huff, M. & Schwan, S. (2012). The Verbal Facilitation Effect in Learning to Tie Nautical Knots. *Learning and Instruction, 22*(5), 376 - 385. doi:10.1016/j.learninstruc.2012.03.001 S

18. Kukulska-Hulme, A. (2012). How Should the Higher Education H

Workforce Adapt to Advancements in Technology for Teaching and Learning?. *Internet and Higher Education, 15*(4), 247 - 254. doi:10.1016/j.iheduc.2011.12.002

19. Hakkinen, P. & Hamalainen, R. (2012). Shared and Personal Learning Spaces: Challenges for Pedagogical Design. *Internet and Higher Education, 15*(4), 231 - 236. doi:10.1016/j.iheduc.2011.09.001 H

20. Wasson, B. & Vold, V. (2012). Leveraging New Media Skills in a Peer Feedback Tool. *Internet and Higher Education, 15*(4), 255 - 264. doi:10.1016/j.iheduc.2011.10.002 H

21. Kress, G. & Selander, S. (2012). Multimodal Design, Learning and Cultures of Recognition. *Internet and Higher Education, 15*(4), 265 - 268. doi:10.1016/j.iheduc.2011.12.003 S

22. Jaworski, N. (2012). Soundwalks, Community, and the Secondary General Classroom. *General Music Today, 26*(1), 34 - 37. doi:10.1177/1048371312453842 H

23. Dudeney, G. & Hockly, N. (2012). ICT in ELT: How Did We Get Here and Where Are We Going?. *ELT Journal, 66*(4), 533 - 542. doi:10.1093/elt/ccs050 H

24. Menkhoff, T. & Bengtsson, M. (2012). Engaging Students in Higher Education through Mobile Learning: Lessons Learnt in a Chinese Entrepreneurship Course. *Educational Research for Policy and Practice, 11*(3), 225 - 242. doi:10.1007/s10671-011-9123-8 H

25. Pamuk, S. (2012). Understanding Preservice Teachers' Technology Use through TPACK Framework. *Journal of Computer Assisted Learning, 28*(5), 425 - 439. doi:10.1111/j.1365-2729.2011.00447.x H

26. Jones, M., Antonenko, P. & Greenwood, C. (2012). The Impact of Collaborative and Individualized Student Response System Strategies on Learner Motivation, Metacognition, and Knowledge Transfer. *Journal of Computer Assisted Learning, 28*(5), 477 - 487. doi:10.1111/j.1365-2729.2011.00470.x S

27. Wong, L., Chen, W. & Jan, M. (2012). How Artefacts Mediate Small-Group Co-Creation Activities in a Mobile-Assisted Seamless Language Learning Environment?. *Journal of Computer Assisted Learning, 28*(5), H

411 - 424. doi:10.1111/j.1365-2729.2011.00445.x

28. Tondeur, J., van Braak, J., Sang, G., Voogt, J., Fisser, P. & Ottenbreit-Leftwich, A. (2012). Preparing Pre-Service Teachers to Integrate Technology in Education: A Synthesis of Qualitative Evidence. *Computers & Education, 59*(1), 134 - 144. doi:10.1016/j.compedu.2011.10.009 H

29. San Diego, J., Cox, M., Quinn, B., Newton, J., Banerjee, A. & Woolford, M. (2012). Researching Haptics in Higher Education: The Complexity of Developing Haptics Virtual Learning Systems and Evaluating Its Impact on Students' Learning. *Computers & Education, 59*(1), 156 - 166. doi:10.1016/j.compedu.2011.11.009 H

30. Whitworth, A. (2012). Invisible Success: Problems with the Grand Technological Innovation in Higher Education. *Computers & Education, 59*(1), 145 - 155. doi:10.1016/j.compedu.2011.09.023 ?

31. Eagle, S. (2012). Learning in the Early Years: Social Interactions around Picturebooks, Puzzles and Digital Technologies. *Computers & Education, 59*(1), 38 - 49. doi:10.1016/j.compedu.2011.10.013 H

32. Freeman, B. (2012). Using Digital Technologies to Redress Inequities for English Language Learners in the English Speaking Mathematics Classroom. *Computers & Education, 59*(1), 50 - 62. doi:10.1016/j.compedu.2011.11.003 H

33. Raes, A., Schellens, T., De Wever, B. & Vanderhoven, E. (2012). Scaffolding Information Problem Solving in Web-Based Collaborative Inquiry Learning. *Computers & Education, 59*(1), 82 - 94. doi:10.1016/j.compedu.2011.11.010 H

34. Plowman, L., Stevenson, O., Stephen, C. & McPake, J. (2012). Preschool Children's Learning with Technology at Home. *Computers & Education, 59*(1), 30 - 37. doi:10.1016/j.compedu.2011.11.014 H

35. Halpern, D., Millis, K., Graesser, A., Butler, H., Forsyth, C. & Cai, Z. (2012). Operation ARA: A Computerized Learning Game that Teaches Critical Thinking and Scientific Reasoning. *Thinking Skills and Creativity, 7*(2), 93 - 100. doi:10.1016/j.tsc.2012.03.006 H

36. Veletsianos, G. (2012). Higher Education Scholars' Participation and Practices on Twitter. *Journal of Computer Assisted Learning, 28*(4), H

336 - 349. doi:10.1111/j.1365-2729.2011.00449.x

37. Wang, Y., Harrington, M. & White, P. (2012). Detecting Breakdowns in Local Coherence in the Writing of Chinese English Learners. *Journal of Computer Assisted Learning, 28*(4), 396 - 410. doi:10.1111/j.1365-2729.2011.00475.x H

38. Chao, K., Hung, I. & Chen, N. (2012). On the Design of Online Synchronous Assessments in a Synchronous Cyber Classroom. *Journal of Computer Assisted Learning, 28*(4), 379 - 395. doi:10.1111/j.1365-2729.2011.00463.x H

39. van Schaik, P., Martin, S. & Vallance, M. (2012). Measuring Flow Experience in an Immersive Virtual Environment for Collaborative Learning. *Journal of Computer Assisted Learning, 28*(4), 350 - 365. doi:10.1111/j.1365-2729.2011.00455.x H

40. Sha, L., Looi, C., Chen, W. & Zhang, B. (2012). Understanding Mobile Learning from the Perspective of Self-Regulated Learning. *Journal of Computer Assisted Learning, 28*(4), 366 - 378. doi:10.1111/j.1365-2729.2011.00461.x H

41. Alcoholado, C., Nussbaum, M., Tagle, A., Gomez, F., Denardin, F., Susaeta, H., Villalta, M. & Toyama, K. (2012). One Mouse per Child: Interpersonal Computer for Individual Arithmetic Practice. *Journal of Computer Assisted Learning, 28*(4), 295 - 309. doi:10.1111/j.1365-2729.2011.00438.x H

42. Kim, H., Miller, H., Herbert, B., Pedersen, S. & Loving, C. (2012). Using a Wiki in a Scientist-Teacher Professional Learning Community: Impact on Teacher Perception Changes. *Journal of Science Education and Technology, 21*(4), 440 - 452. doi:10.1007/s10956-011-9336-x H

43. Tsai, C., Jack, B., Huang, T. & Yang, J. (2012). Using the Cognitive Apprenticeship Web-Based Argumentation System to Improve Argumentation Instruction. *Journal of Science Education and Technology, 21*(4), 476 - 486. doi:10.1007/s10956-011-9339-7 H

44. Powell, D., Jacob, C. & Chapman, B. (2012). Using Blogs and New Media in Academic Practice: Potential Roles in Research, Teaching, Learning, and Extension. *Innovative Higher Education, 37*(4), 271 - 282. doi:10.1007/s10755-011-9207-7 H

45. Yates, L. (2012). "My School, My University, My Country, My World, My Google, Myself"...What Is Education for Now? *Australian Educational Researcher, 39*(3), 259 - 274. doi:10.1007/s13384-012-0062-z H

46. Remedios, L., Clarke, D. & Hawthorne, L. (2012). Learning to Listen and Listening to Learn: One Student's Experience of Small Group Collaborative Learning. *Australian Educational Researcher, 39*(3), 333 - 348. doi:10.1007/s13384-012-0064-x S

47. Kennedy, M., Ely, E., Thomas, C., Pullen, P., Newton, J., Ashworth, K., Cole, M. & Lovelace, S. (2012). Using Multimedia Tools to Support Teacher Candidates' Learning. *Teacher Education and Special Education, 35*(3), 243 - 257. doi:10.1177/0888406412451158 H

48. Mazurek, M., Shattuck, P., Wagner, M. & Cooper, B. (2012). Prevalence and Correlates of Screen-Based Media Use among Youths with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders, 42*(8), 1757 - 1767. doi:10.1007/s10803-011-1413-8 H

49. Armellini, A. & Hawkridge, D. (2012). Utopian Universities: A Technicist's Dream. *Journal of Computing in Higher Education, 24*(2), 132 - 142. doi:10.1007/s12528-012-9058-y H

50. Schwier, R. (2012). The Corrosive Influence of Competition, Growth, and Accountability on Institutions of Higher Education. *Journal of Computing in Higher Education, 24*(2), 96 - 103. doi:10.1007/s12528-012-9057-z S

51. Ross, S. & Morrison, G. (2012). Constructing a Deconstructed Campus: Instructional Design as Vital Bricks and Mortar. *Journal of Computing in Higher Education, 24*(2), 119 - 131. doi:10.1007/s12528-012-9056-0 H

52. Shrock, S. (2012). A Reaction to Mazoue's Deconstructed Campus. *Journal of Computing in Higher Education, 24*(2), 104 - 118. doi:10.1007/s12528-012-9055-1 H

53. Van Zoest, L., Stockero, S. & Taylor, C. (2012). The Durability of Professional and Sociomathematical Norms Intentionally Fostered in an Early Pedagogy Course. *Journal of Mathematics Teacher* S

Education, 15(4), 293 - 315. doi:10.1007/s10857-011-9183-y

54. Chong, S. & Lee, C. (2012). Developing a Pedagogical-Technical Framework to Improve Creative Writing. *Educational Technology Research and Development, 60*(4), 639 - 657. doi:10.1007/s11423-012-9242-9 H

55. Nedungadi, P. & Raman, R. (2012). A New Approach to Personalization: Integrating E-Learning and M-Learning. *Educational Technology Research and Development, 60*(4), 659 - 678. doi:10.1007/s11423-012-9250-9 H

56. Song, Y., Wong, L. & Looi, C. (2012). Fostering Personalized Learning in Science Inquiry Supported by Mobile Technologies. *Educational Technology Research and Development, 60*(4), 679 - 701. doi:10.1007/s11423-012-9245-6 H

57. Hwang, G., Sung, H., Hung, C., Huang, I. & Tsai, C. (2012). Development of a Personalized Educational Computer Game Based on Students' Learning Styles. *Educational Technology Research and Development, 60*(4), 623 - 638. doi:10.1007/s11423-012-9241-x H

58. Karmeshu, Raman, R. & Nedungadi, P. (2012). Modelling Diffusion of a Personalized Learning Framework. *Educational Technology Research and Development, 60*(4), 585 - 600. doi:10.1007/s11423-012-9249-2 S

59. Huang, Y., Liang, T., Su, Y. & Chen, N. (2012). Empowering Personalized Learning with an Interactive E-Book Learning System for Elementary School Students. *Educational Technology Research and Development, 60*(4), 703 - 722. doi:10.1007/s11423-012-9237-6 H

60. Kutay, C., Mooney, J., Riley, L. & Howard-Wagner, D. (2012). Experiencing Indigenous Knowledge Online as a Community Narrative. *Australian Journal of Indigenous Education, 41*(1), 47 - 59. doi:10.1017/jie.2012.8 H

61. Vernadakis, N., Gioftsidou, A., Antoniou, P., Ioannidis, D. & Giannousi, M. (2012). The Impact of Nintendo Wii to Physical Education Students' Balance Compared to the Traditional Approaches. *Computers & Education, 59*(2), 196 - 205. doi:10.1016/j.compedu.2012.01.003 H

62. Shieh, R. (2012). The Impact of Technology-Enabled Active Learning (TEAL) Implementation on Student Learning and Teachers' Teaching in a High School Context. *Computers & Education, 59*(2), 206 - 214. doi:10.1016/j.compedu.2012.01.016 H

63. Spanjers, I., van Gog, T., Wouters, P. & van Merrienboer, J. (2012). Explaining the Segmentation Effect in Learning from Animations: The Role of Pausing and Temporal Cueing. *Computers & Education, 59*(2), 274 - 280. doi:10.1016/j.compedu.2011.12.024 S

64. Robertson, J. (2012). Making Games in the Classroom: Benefits and Gender Concerns. *Computers & Education, 59*(2), 385 - 398. doi:10.1016/j.compedu.2011.12.020 S

65. Ottenbreit-Leftwich, A., Brush, T., Strycker, J., Gronseth, S., Roman, T., Abaci, S., vanLeusen, P., Shin, S., Easterling, W. & Plucker, J. (2012). Preparation versus Practice: How Do Teacher Education Programs and Practicing Teachers Align in Their Use of Technology to Support Teaching and Learning? *Computers & Education, 59*(2), 399 - 411. doi:10.1016/j.compedu.2012.01.014 H

66. Wiseman, A. & Anderson, E. (2012). ICT-Integrated Education and National Innovation Systems in the Gulf Cooperation Council (GCC) Countries. *Computers & Education, 59*(2), 607 - 618. doi:10.1016/j.compedu.2012.02.006 H

67. Yang, Y. (2012). Building Virtual Cities, Inspiring Intelligent Citizens: Digital Games for Developing Students' Problem Solving and Learning Motivation. *Computers & Education, 59*(2), 365 - 377. doi:10.1016/j.compedu.2012.01.012 H

68. Ertmer, P., Ottenbreit-Leftwich, A., Sadik, O., Sendurur, E. & Sendurur, P. (2012). Teacher Beliefs and Technology Integration Practices: A Critical Relationship. *Computers & Education, 59*(2), 423 - 435. doi:10.1016/j.compedu.2012.02.001 H

69. Lai, C., Wang, Q. & Lei, J. (2012). What Factors Predict Undergraduate Students' Use of Technology for Learning? A Case from Hong Kong. *Computers & Education, 59*(2), 569 - 579. doi:10.1016/j.compedu.2012.03.006 H

70. Nistor, N., Schworm, S. & Werner, M. (2012). Online Help-Seeking in Communities of Practice: Modeling the Acceptance of Conceptual H

Artifacts. *Computers & Education, 59*(2), 774 - 784. doi:10.1016/j.compedu.2012.03.017

71. Hamalainen, R. & Oksanen, K. (2012). Challenge of Supporting Vocational Learning: Empowering Collaboration in a Scripted 3D Game--How Does Teachers' Real-Time Orchestration Make a Difference?. Computers & Education, 59(2), 281 - 293. doi:10.1016/j.compedu.2012.01.002 H

72. Jang, S. & Tsai, M. (2012). Exploring the TPACK of Taiwanese Elementary Mathematics and Science Teachers with Respect to Use of Interactive Whiteboards. Computers & Education, 59(2), 327 - 338. doi:10.1016/j.compedu.2012.02.003 H

73. Koh, E. & Lim, J. (2012). Using Online Collaboration Applications for Group Assignments: The Interplay between Design and Human Characteristics. Computers & Education, 59(2), 481 - 496. doi:10.1016/j.compedu.2012.02.002 H

74. Zou, J., Liu, Q. & Yang, Z. (2012). Development of a Moodle Course for Schoolchildren's Table Tennis Learning Based on Competence Motivation Theory: Its Effectiveness in Comparison to Traditional Training Method. Computers & Education, 59(2), 294 - 303. doi:10.1016/j.compedu.2012.01.008 H

75. Wecker, C. (2012). Slide Presentations as Speech Suppressors: When and Why Learners Miss Oral Information. Computers & Education, 59(2), 260 - 273. doi:10.1016/j.compedu.2012.01.013 H

76. Lin, H., Hong, Z. & Lawrenz, F. (2012). Promoting and Scaffolding Argumentation through Reflective Asynchronous Discussions. Computers & Education, 59(2), 378 - 384. doi:10.1016/j.compedu.2012.01.019 H

77. Yilmaz, R. & Kilic-Cakmak, E. (2012). Educational Interface Agents as Social Models to Influence Learner Achievement, Attitude and Retention of Learning. Computers & Education, 59(2), 828 - 838. doi:10.1016/j.compedu.2012.03.020 H

78. Kay, R. & Kletskin, I. (2012). Evaluating the Use of Problem-Based Video Podcasts to Teach Mathematics in Higher Education. Computers & Education, 59(2), 619 - 627. doi:10.1016/j.compedu.2012.03.007 H

79. Yang, Y. & Wu, W. (2012). Digital Storytelling for Enhancing Student Academic Achievement, Critical Thinking, and Learning Motivation: A Year-Long Experimental Study. Computers & Education, 59(2), 339 - 352. doi:10.1016/j.compedu.2011.12.012 H

80. Bennett, S., Bishop, A., Dalgarno, B., Waycott, J. & Kennedy, G. (2012). Implementing Web 2.0 Technologies in Higher Education: A Collective Case Study. Computers & Education, 59(2), 524 - 534. doi:10.1016/j.compedu.2011.12.022 H

81. Meluso, A., Zheng, M., Spires, H. & Lester, J. (2012). Enhancing 5th Graders' Science Content Knowledge and Self-Efficacy through Game-Based Learning. *Computers & Education, 59*(2), 497 - 504. doi:10.1016/j.compedu.2011.12.019 H

82. Brito, P. (2012). Tweens' Characterization of Digital Technologies. *Computers & Education, 59*(2), 580 - 593. doi:10.1016/j.compedu.2012.03.005 H

83. Wu, W., Wu, Y., Chen, C., Kao, H., Lin, C. & Huang, S. (2012). Review of Trends from Mobile Learning Studies: A Meta-Analysis. *Computers & Education, 59*(2), 817 - 827. doi:10.1016/j.compedu.2012.03.016 H

84. Silvennoinen, M., Helfenstein, S., Ruoranen, M. & Saariluoma, P. (2012). Learning Basic Surgical Skills through Simulator Training. *Instructional Science: An International Journal of the Learning Sciences, 40*(5), 769 - 783. doi:10.1007/s11251-012-9217-6 H

85. Nivala, M., Saljo, R., Rystedt, H., Kronqvist, P. & Lehtinen, E. (2012). Using Virtual Microscopy to Scaffold Learning of Pathology: A Naturalistic Experiment on the Role of Visual and Conceptual Cues. *Instructional Science: An International Journal of the Learning Sciences, 40*(5), 799 - 811. doi:10.1007/s11251-012-9215-8 H

86. Perez-Sanagustin, M., Santos, P., Hernandez-Leo, D. & Blat, J. (2012). 4SPPIces: A Case Study of Factors in a Scripted Collaborative-Learning Blended Course across Spatial Locations. *International Journal of Computer-Supported Collaborative Learning, 7*(3), 443 - 465. doi:10.1007/s11412-011-9139-3 H

87. MacKinnon, K. (2012). Context Matters: The Value of Analyzing Human Factors within Educational Contexts as a Way of Informing S

Technology-Related Decisions within Design Research. *International Journal of Computer-Supported Collaborative Learning, 7*(3), 379 - 397. doi:10.1007/s11412-012-9149-9

88. Young, M., Slota, S. & Lai, B. (2012). Comments on "Reflections on 'A Review of Trends in Serious Gaming'". *Review of Educational Research, 82*(3), 296 - 299. doi:10.3102/0034654312456606 H

89. Sooraksa, N. (2012). Using Computer-Based Continuing Professional Education of Training Staff to Develop Small- and Medium-Sized Enterprises in Thailand. *International Journal of Training and Development, 16*(3), 235 - 242. doi:10.1111/j.1468-2419.2012.00407.x H

90. Merchant, G. (2012). Mobile Practices in Everyday Life: Popular Digital Technologies and Schooling Revisited. *British Journal of Educational Technology, 43*(5), 770 - 782. doi:10.1111/j.1467-8535.2012.01352.x H

91. Pimmer, C., Linxen, S. & Grohbiel, U. (2012). Facebook as a Learning Tool? A Case Study on the Appropriation of Social Network Sites from Mobile Phones in Developing Countries. *British Journal of Educational Technology, 43*(5), 726 - 738. doi:10.1111/j.1467-8535.2012.01351.x H

92. Terras, M. & Ramsay, J. (2012). The Five Central Psychological Challenges Facing Effective Mobile Learning. *British Journal of Educational Technology, 43*(5), 820 - 832. doi:10.1111/j.1467-8535.2012.01362.x H

93. Turvey, K. (2012). Questioning the Character and Significance of Convergence between Social Network and Professional Practices in Teacher Education. *British Journal of Educational Technology, 43*(5), 739 - 753. doi:10.1111/j.1467-8535.2012.01358.x H

94. Gao, F., Luo, T. & Zhang, K. (2012). Tweeting for Learning: A Critical Analysis of Research on Microblogging in Education Published in 2008-2011. *British Journal of Educational Technology, 43*(5), 783 - 801. doi:10.1111/j.1467-8535.2012.01357.x H

95. Bouck, E., Maeda, Y. & Flanagan, S. (2012). Assistive Technology and Students with High-Incidence Disabilities: Understanding the Relationship through the NLTS2. *Remedial and Special Education,* H

33(5), 298 - 308. doi:10.1177/0741932511401037

96. Cook, J. & Pachler, N. (2012). Online People Tagging: Social (Mobile) Network(ing) Services and Work-Based Learning. *British Journal of Educational Technology, 43*(5), 711 - 725. doi:10.1111/j.1467-8535.2012.01346.x H

97. Charitonos, K., Blake, C., Scanlon, E. & Jones, A. (2012). Museum Learning via Social and Mobile Technologies: (How) Can Online Interactions Enhance the Visitor Experience? *British Journal of Educational Technology, 43*(5), 802 - 819. doi:10.1111/j.1467-8535.2012.01360.x H

98, Hutchison, A., Beschorner, B. & Schmidt-Crawford, D. (2012). Exploring the Use of the iPad for Literacy Learning. *Reading Teacher, 66*(1), 15 - 23. doi:10.1002/TRTR.01090 H

99. Coates, R. (2012). Accommodating Band Students with Visual Impairments. *Music Educators Journal, 99*(1), 60 - 66. doi:10.1177/0027432112448478 S

100. Tripp, T. & Rich, P. (2012). The Influence of Video Analysis on the Process of Teacher Change. Teaching and Teacher Education: An *International Journal of Research and Studies, 28*(5), 728 - 739. doi:10.1016/j.tate.2012.01.011 S

101. Dovis, S., van der Oord, S., Wiers, R. & Prins, P. (2012). Can Motivation Normalize Working Memory and Task Persistence in Children with Attention-Deficit/Hyperactivity Disorder? The Effects of Money and Computer-Gaming. *Journal of Abnormal Child Psychology, 40*(5), 669 - 681. doi:10.1007/s10802-011-9601-8 S

102. Kardos, L. (2012). How Music Technology Can Make Sound and Music Worlds Accessible to Student Composers in Further Education Colleges. *British Journal of Music Education, 29*(2), 143 - 151. doi:10.1017/S0265051712000186 H

103. Hsu, C., Hwang, G., Chuang, C. & Chang, C. (2012). Effects on Learners' Performance of Using Selected and Open Network Resources in a Problem-Based Learning Activity. *British Journal of Educational Technology, 43*(4), 606 - 623. doi:10.1111/j.1467-8535.2011.01235.x H

104. McDonald, S. & Howell, J. (2012). Watching, Creating and Achieving: Creative Technologies as a Conduit for Learning in the Early Years. *British Journal of Educational Technology, 43*(4), 641 - 651. doi:10.1111/j.1467-8535.2011.01231.x H

105. Hou, H. & Cheng, K. (2012). Analyzing the Latent Emotional Transfer Pattern (LETP) of a Learning Community in an Online Peer-Assessment Activity. *British Journal of Educational Technology, 43*(4). doi:10.1111/j.1467-8535.2012.01301.x H

106. Miranda, H. & Russell, M. (2012). Understanding Factors Associated with Teacher-Directed Student Use of Technology in Elementary Classrooms: A Structural Equation Modeling Approach. *British Journal of Educational Technology, 43*(4), 652 - 666. doi:10.1111/j.1467-8535.2011.01228.x H

107. Shin, N., Sutherland, L., Norris, C. & Soloway, E. (2012). Effects of Game Technology on Elementary Student Learning in Mathematics. *British Journal of Educational Technology, 43*(4), 540 - 560. doi:10.1111/j.1467-8535.2011.01197.x H

108. Gomez, E. & Rodriguez-Marciel, C. (2012). PGDnet: A New Problem-Solving Virtual Learning Environment. *British Journal of Educational Technology, 43*(4), 576 - 591. doi:10.1111/j.1467-8535.2011.01224.x H

109. Park, S., Nam, M. & Cha, S. (2012). University Students' Behavioral Intention to Use Mobile Learning: Evaluating the Technology Acceptance Model. *British Journal of Educational Technology, 43*(4), 592 - 605. doi:10.1111/j.1467-8535.2011.01229.x H

110. Peluso, D. (2012). The Fast-Paced iPad Revolution: Can Educators Stay up to Date and Relevant about These Ubiquitous Devices?. *British Journal of Educational Technology, 43*(4). doi:10.1111/j.1467-8535.2012.01310.x H

111. Wang, M. & Shen, R. (2012). Message Design for Mobile Learning: Learning Theories, Human Cognition and Design Principles. *British Journal of Educational Technology, 43*(4), 561 - 575. doi:10.1111/j.1467-8535.2011.01214.x S

112. Towndrow, P. & Wan, F. (2012). Professional Learning during a One-to-One Laptop Innovation. *Journal of Technology and Teacher* H

Education, 20(3), 331 - 355.

113. Strayer, J. (2012). How Learning in an Inverted Classroom Influences Cooperation, Innovation and Task Orientation. *Learning Environments Research, 15*(2), 171 - 193. doi:10.1007/s10984-012-9108-4 H

114. Gupta, A. & Fisher, D. (2012). Technology-Supported Learning Environments in Science Classrooms in India. *Learning Environments Research, 15*(2), 195 - 216. doi:10.1007/s10984-012-9103-9 H

115. Krauskopf, K., Zahn, C. & Hesse, F. (2012). Leveraging the Affordances of YouTube: The Role of Pedagogical Knowledge and Mental Models of Technology Functions for Lesson Planning with Technology. *Computers & Education, 58*(4), 1194 - 1206. doi:10.1016/j.compedu.2011.12.010 H

116. Romero-Zaldivar, V., Pardo, A., Burgos, D. & Delgado Kloos, C. (2012). Monitoring Student Progress Using Virtual Appliances: A Case Study. *Computers & Education, 58*(4), 1058 - 1067. doi:10.1016/j.compedu.2011.12.003 H

117. Wu, H. & Lin, H. (2012). A Hybrid Approach to Develop an Analytical Model for Enhancing the Service Quality of E-Learning. *Computers & Education, 58*(4), 1318 - 1338. doi:10.1016/j.compedu.2011.12.025 H

118. Vangsnes, V., Gram Okland, N. & Krumsvik, R. (2012). Computer Games in Pre-School Settings: Didactical Challenges when Commercial Educational Computer Games Are Implemented in Kindergartens. *Computers & Education, 58*(4), 1138 - 1148. doi:10.1016/j.compedu.2011.12.018 H

119. Korallo, L., Foreman, N., Boyd-Davis, S., Moar, M. & Coulson, M. (2012). Do Challenge, Task Experience or Computer Familiarity Influence the Learning of Historical Chronology from Virtual Environments in 8-9 Year Old Children? *Computers & Education, 58*(4), 1106 - 1116. doi:10.1016/j.compedu.2011.12.011 H

120. Escobar-Rodriguez, T. & Monge-Lozano, P. (2012). The Acceptance of Moodle Technology by Business Administration Students. *Computers & Education, 58*(4), 1085 - 1093. doi:10.1016/j.compedu.2011.11.012 H

121. Petko, D. (2012). Teachers' Pedagogical Beliefs and Their Use of Digital Media in Classrooms: Sharpening the Focus of the "Will, Skill, Tool" Model and Integrating Teachers' Constructivist Orientations. *Computers & Education, 58*(4), 1351 - 1359. doi:10.1016/j.compedu.2011.12.013 H

122. Craig, S., Gholson, B., Brittingham, J., Williams, J. & Shubeck, K. (2012). Promoting Vicarious Learning of Physics Using Deep Questions with Explanations. *Computers & Education, 58*(4), 1042 - 1048. doi:10.1016/j.compedu.2011.11.018 H

123. Perez-Mateo, M. & Guitert, M. (2012). Which Social Elements Are Visible in Virtual Groups? Addressing the Categorization of Social Expressions. *Computers & Education, 58*(4), 1234 - 1246. doi:10.1016/j.compedu.2011.12.014 S

124. Gedik, N., Hanci-Karademirci, A., Kursun, E. & Cagiltay, K. (2012). Key Instructional Design Issues in a Cellular Phone-Based Mobile Learning Project. *Computers & Education, 58*(4), 1149 - 1159. doi:10.1016/j.compedu.2011.12.002 H

125. Paus, E., Werner, C. & Jucks, R. (2012). Learning through Online Peer Discourse: Structural Equation Modeling Points to the Role of Discourse Activities in Individual Understanding. *Computers & Education, 58*(4), 1127 - 1137. doi:10.1016/j.compedu.2011.12.008 H

126. Hwang, W., Shadiev, R., Wang, C. & Huang, Z. (2012). A Pilot Study of Cooperative Programming Learning Behavior and Its Relationship with Students' Learning Performance. *Computers & Education, 58*(4), 1267 - 1281. doi:10.1016/j.compedu.2011.12.009 H

127. Tsuei, M. (2012). Using Synchronous Peer Tutoring System to Promote Elementary Students' Learning in Mathematics. *Computers & Education, 58*(4), 1171 - 1182. doi:10.1016/j.compedu.2011.11.025 H

128. Deutsch, T., Herrmann, K., Frese, T. & Sandholzer, H. (2012). Implementing Computer-Based Assessment--A Web-Based Mock Examination Changes Attitudes. *Computers & Education, 58*(4), 1068 - 1075. doi:10.1016/j.compedu.2011.11.013 H

129. Elwood, J. & MacLean, G. (2012). To Use or Not to Use: Psychometric Properties of the Willingness to Use Technology (WUT) Instrument in Three Asian Contexts. *Computers & Education, 58*(4), 1360 - 1371. H

doi:10.1016/j.compedu.2011.11.008

130. Pynoo, B., Tondeur, J., van Braak, J., Duyck, W., Sijnave, B. & Duyck, P. (2012). Teachers' Acceptance and Use of an Educational Portal. *Computers & Education, 58*(4), 1308 - 1317. doi:10.1016/j.compedu.2011.12.026 H

131. Chen, Y., Hwang, R. & Wang, C. (2012). Development and Evaluation of a Web 2.0 Annotation System as a Learning Tool in an E-Learning Environment. *Computers & Education, 58*(4), 1094 - 1105. doi:10.1016/j.compedu.2011.12.017 H

132. Govaere Jan, L., de Kruif, A. & Valcke, M. (2012). Differential Impact of Unguided versus Guided Use of a Multimedia Introduction to Equine Obstetrics in Veterinary Education. *Computers & Education, 58*(4), 1076 - 1084. doi:10.1016/j.compedu.2011.11.006 H

133. Marturana, E. & Woods, J. (2012). Technology-Supported Performance-Based Feedback for Early Intervention Home Visiting. *Topics in Early Childhood Special Education, 32*(1), 14 - 23. doi:10.1177/0271121411434935 H

134. Tu, C., Sujo-Montes, L., Yen, C., Chan, J. & Blocher, M. (2012). The Integration of Personal Learning Environments & Open Network Learning Environments. *TechTrends: Linking Research and Practice to Improve Learning, 56*(3), 13 - 19. doi:10.1007/s11528-012-0571-7 H

135. Lowdermilk, J., Martinez, D., Pecina, J., Beccera, L. & Lowdermilk, C. (2012). Behavior Breakthroughs[TM]: Future Teachers Reflect on a Focused Game Designed to Teach ABA Techniques. *TechTrends: Linking Research and Practice to Improve Learning, 56*(3), 29 - 35. doi:10.1007/s11528-012-0573-5 H

136. McClanahan, B., Williams, K., Kennedy, E. & Tate, S. (2012). A Breakthrough for Josh: How Use of an iPad Facilitated Reading Improvement. *TechTrends: Linking Research and Practice to Improve Learning, 56*(3), 20 - 28. doi:10.1007/s11528-012-0572-6 H

137. Chien, Y., Chang, C., Yeh, T. & Chang, K. (2012). Engaging Pre-Service Science Teachers to Act as Active Designers of Technology Integration: A MAGDAIRE Framework. *Teaching and Teacher Education: An International Journal of Research and Studies, 28*(4), H

578 - 588. doi:10.1016/j.tate.2011.12.005

138. Carmichael, P. (2012). Tribes, Territories and Threshold Concepts: Educational Materialisms at Work in Higher Education. *Educational Philosophy and Theory, 44*, 31 - 42. doi:10.1111/j.1469-5812.2010.00743.x ?

139. Moridis, C. & Economides, A. (2012). Applause as an Achievement-Based Reward during a Computerised Self-Assessment Test. *British Journal of Educational Technology, 43*(3), 489 - 504. doi:10.1111/j.1467-8535.2011.01221.x H

140. Yang, Y., Gamble, J. & Tang, S. (2012). Voice over Instant Messaging as a Tool for Enhancing the Oral Proficiency and Motivation of English-as-a-Foreign-Language Learners. *British Journal of Educational Technology, 43*(3), 448 - 464. doi:10.1111/j.1467-8535.2011.01204.x H

141. Rubin, D., Richards, C., Keene, P., Paiker, J., Gray, A., Herron, R., Russell, M. & Wigdorowitz, B. (2012). System Dynamics in Medical Education: A Tool for Life. *Advances in Health Sciences Education, 17*(2), 203 - 210. doi:10.1007/s10459-010-9237-4 S

142. Yalcinalp, S. & Emiroglu, B. (2012). Through Efficient Use of LORs: Prospective Teachers' Views on Operational Aspects of Learning Object Repositories. *British Journal of Educational Technology, 43*(3), 474 - 488. doi:10.1111/j.1467-8535.2011.01212.x H

143. Bowman, C. (2012). Student Use of Animated Pedagogical Agents in a Middle School Science Inquiry Program. *British Journal of Educational Technology, 43*(3), 359 - 375. doi:10.1111/j.1467-8535.2011.01198.x H

144. Calder, N. (2012). The Layering of Mathematical Interpretations through Digital Media. *Educational Studies in Mathematics, 80*, 269 - 285. doi:10.1007/s10649-011-9365-7 H

145. Williams, P. (2012). Investigating the Feasibility of Using Digital Representations of Work for Performance Assessment in Engineering. *International Journal of Technology and Design Education, 22*(2), 187 - 203. doi:10.1007/s10798-011-9192-2 H

146. Vanderlinde, R., Dexter, S. & van Braak, J. (2012). School-Based ICT Policy Plans in Primary Education: Elements, Typologies and Underlying Processes. *British Journal of Educational Technology, 43*(3), 505 - 519. doi:10.1111/j.1467-8535.2011.01191.x H

147. Davies, D., Collier, C. & Howe, A. (2012). Assessing Scientific and Technological Enquiry Skills at Age 11 Using the E-Scape System. *International Journal of Technology and Design Education, 22*(2), 247 - 263. doi:10.1007/s10798-011-9191-3 H

148. McLaren, S. (2012). Assessment Is for Learning: Supporting Feedback. *International Journal of Technology and Design Education, 22*(2), 227 - 245. doi:10.1007/s10798-011-9195-z H

149. Sorgo, A. & Kocijancic, S. (2012). False Reality or Hidden Messages: Reading Graphs Obtained in Computerized Biological Experiments. EURASIA *Journal of Mathematics, Science & Technology Education, 8*(2), 129 - 137. H

150. Zhu, Y., Fung, A. & Wang, H. (2012). Memorization Effects of Pronunciation and Stroke Order Animation in Digital Flashcards. *CALICO Journal, 29*(3), 563 - 577. H

151. Arnold, N., Ducate, L. & Kost, C. (2012). Collaboration or Cooperation? Analyzing Group Dynamics and Revision Processes in Wikis. *CALICO Journal, 29*(3), 431 - 448. H

152. Pardo-Ballester, C. (2012). CALL Evaluation: Students' Perception and Use of LoMasTv. *CALICO Journal, 29*(3), 532 - 547. H

153. Wang, S. & Vasquez, C. (2012). Web 2.0 and Second Language Learning: What Does the Research Tell Us? *CALICO Journal, 29*(3), 412 - 430. H

154. Cihak, D., Kildare, L., Smith, C., McMahon, D. & Quinn-Brown, L. (2012). Using Video Social Stories[TM] to Increase Task Engagement for Middle School Students with Autism Spectrum Disorders. *Behavior Modification, 36*(3), 399 - 425. doi:10.1177/0145445512442683 H

155. Reed, Y. (2012). Critical Pedagogic Analysis: An Alternative to User Feedback for (Re)Designing Distance Learning Materials for Language Teachers? *English Teaching: Practice and Critique, 11*(1), 60 - 81. S

156. Bhanji, Z. (2012). Transnational Private Authority in Education Policy in Jordan and South Africa: The Case of Microsoft Corporation. *Comparative Education Review, 56*(2), 300 - 319. doi:10.1086/664041 H

157. Bartholomew, M., Jones, T. & Glassman, M. (2012). A Community of Voices: Educational Blog Management Strategies and Tools. *TechTrends: Linking Research and Practice to Improve Learning, 56*(4), 19 - 25. doi:10.1007/s11528-012-0583-3 H

158. Denton, D. (2012). Enhancing Instruction through Constructivism, Cooperative Learning, and Cloud Computing. *TechTrends: Linking Research and Practice to Improve Learning, 56*(4), 34 - 41. doi:10.1007/s11528-012-0585-1 H

159. Fan, C. & Ho, K. (2012). A Tale of Three Cities: Review of the Development of ICT in School Education between Hong Kong, Macau and Singapore. *New Horizons in Education, 60*(1), 70 - 82. H

160. Owusu, Y., Kunik, M., Coverdale, J., Shah, A., Primm, A. & Harris, T. (2012). Lessons Learned: A "Homeless Shelter Intervention" by a Medical Student. *Academic Psychiatry, 36*(3), 219 - 222. doi:10.1176/appi.ap.10040055 H

161. Hagood, M. (2012). Risks, Rewards, and Responsibilities of Using New Literacies in Middle Grades. *Voices from the Middle, 19*(4), 10 - 16. H

162. Nichols, P. (2012). From Knowledge to Wisdom: Critical Evaluation in New Literacy Instruction. *Voices from the Middle, 19*(4), 64 - 69. H

163. Wilhelm, J. (2012). Our Compulsory Goals: Effective Teaching and Meaningful Learning through Powerful Cultural Tools. *Voices from the Middle, 19*(4), 81 - 83. S

164. Kist, W. (2012). Middle Schools and New Literacies: Looking Back and Moving Forward. *Voices from the Middle, 19*(4), 17 - 21. S

165. Teng, A. (2012). Writing Teachers Should Comment on Facebook Walls. *Voices from the Middle, 19*(4), 34 - 38. H

166. Goktas, Y. & Demirel, T. (2012). Blog-Enhanced ICT Courses: Examining Their Effects on Prospective Teachers' ICT Competencies H

and Perceptions. *Computers & Education, 58*(3), 908 - 917. doi:10.1016/j.compedu.2011.11.004

167. Benitti, F. (2012). Exploring the Educational Potential of Robotics in Schools: A Systematic Review. *Computers & Education, 58*(3), 978 - 988. doi:10.1016/j.compedu.2011.10.006 H

168. Sad, S. (2012). An Attitude Scale for Smart Board Use in Education: Validity and Reliability Studies. *Computers & Education, 58*(3), 900 - 907. doi:10.1016/j.compedu.2011.10.017 H

169. Yurdakul, I., Odabasi, H., Kilicer, K., Coklar, A., Birinci, G. & Kurt, A. (2012). The Development, Validity and Reliability of TPACK-Deep: A Technological Pedagogical Content Knowledge Scale. *Computers & Education, 58*(3), 964 - 977. doi:10.1016/j.compedu.2011.10.012 H

170. Gurbuz, R. & Birgin, O. (2012). The Effect of Computer-Assisted Teaching on Remedying Misconceptions: The Case of the Subject "Probability". *Computers & Education, 58*(3), 931 - 941. doi:10.1016/j.compedu.2011.11.005 H

171. Chu, S., Chan, C. & Tiwari, A. (2012). Using Blogs to Support Learning during Internship. *Computers & Education, 58*(3), 989 - 1000. doi:10.1016/j.compedu.2011.08.027 H

172. Martinovic, D. & Zhang, Z. (2012). Situating ICT in the Teacher Education Program: Overcoming Challenges, Fulfilling Expectations. *Teaching and Teacher Education: An International Journal of Research and Studies, 28*(3), 461 - 469. doi:10.1016/j.tate.2011.12.001 H

173. Yang, C. & Chang, Y. (2012). Assessing the Effects of Interactive Blogging on Student Attitudes towards Peer Interaction, Learning Motivation, and Academic Achievements. *Journal of Computer Assisted Learning, 28*(2), 126 - 135. doi:10.1111/j.1365-2729.2011.00423.x H

174. Lajoie, S. & Lu, J. (2012). Supporting Collaboration with Technology: Does Shared Cognition Lead to Co-Regulation in Medicine? *Metacognition and Learning, 7*(1), 45 - 62. doi:10.1007/s11409-011-9077-5 H

175. Bernacki, M., Byrnes, J. & Cromley, J. (2012). The Effects of Achievement Goals and Self-Regulated Learning Behaviors on Reading Comprehension in Technology-Enhanced Learning Environments. *Contemporary Educational Psychology, 37*(2), 148 - 161. doi:10.1016/j.cedpsych.2011.12.001 H

176. Baker, M., Bernard, F. & Dumez-Feroc, I. (2012). Integrating Computer-Supported Collaborative Learning into the Classroom: The Anatomy of a Failure. *Journal of Computer Assisted Learning, 28*(2), 161 - 176. doi:10.1111/j.1365-2729.2011.00435.x H

177. Al-Busaidi, K. & Al-Shihi, H. (2012). Key Factors to Instructors' Satisfaction of Learning Management Systems in Blended Learning. *Journal of Computing in Higher Education, 24*(1), 18 - 39. doi:10.1007/s12528-011-9051-x H

178. Trushell, J., Byrne, K. & Simpson, R. (2012). Cheating Behaviours, the Internet and Education Undergraduate Students. *Journal of Computer Assisted Learning, 28*(2), 136 - 145. doi:10.1111/j.1365-2729.2011.00424.x H

179. Hung, J. & Zhang, K. (2012). Examining Mobile Learning Trends 2003-2008: A Categorical Meta-Trend Analysis Using Text Mining Techniques. *Journal of Computing in Higher Education, 24*(1), 1 - 17. doi:10.1007/s12528-011-9044-9 H

180. Burton, W., Civitano, A. & Steiner-Grossman, P. (2012). Online versus Paper Evaluations: Differences in Both Quantitative and Qualitative Data. *Journal of Computing in Higher Education, 24*(1), 58 - 69. doi:10.1007/s12528-012-9053-3 H

181. Lust, G., Elen, J. & Clarebout, G. (2012). Adopting Webcasts over Time: The Influence of Perceptions and Attitudes. *Journal of Computing in Higher Education, 24*(1), 40 - 57. doi:10.1007/s12528-011-9052-9 H

182. Suhonen, J., de Villiers, M. & Sutinen, E. (2012). FODEM: A Multi-Threaded Research and Development Method for Educational Technology. *Educational Technology Research and Development, 60*(2), 287 - 305. doi:10.1007/s11423-011-9223-4 H

183. Vandewaetere, M., Vandercruysse, S. & Clarebout, G. (2012). Learners' Perceptions and Illusions of Adaptivity in Computer-Based H

Learning Environments. *Educational Technology Research and Development, 60*(2), 307 - 324. doi:10.1007/s11423-011-9225-2

184. Lubin, I. & Ge, X. (2012). Investigating the Influences of a LEAPS Model on Preservice Teachers' Problem Solving, Metacognition, and Motivation in an Educational Technology Course. *Educational Technology Research and Development, 60*(2), 239 - 270. doi:10.1007/s11423-011-9224-3 H

185. Slomp, D. (2012). Challenges in Assessing the Development of Writing Ability: Theories, Constructs and Methods. *Assessing Writing, 17*(2), 81 - 91. doi:10.1016/j.asw.2012.02.001 S

186. Kidd, W. (2012). Utilising Podcasts for Learning and Teaching: A Review and Ways Forward for E-Learning Cultures. *Management in Education, 26*(2), 52 - 57. doi:10.1177/0892020612438031 H

187. Woollard, J. (2012). When "Teaching a Class of Daemons, Dragons and Trainee Teachers"--Learning the Pedagogy of the Virtual Classroom. *Management in Education, 26*(2), 45 - 51. doi:10.1177/0892020611431388 H

188. Ellington, H. (2012). How Simulation/Gaming Transformed My Life. *Simulation & Gaming, 43*(2), 257 - 269. doi:10.1177/1046878111432665 S

189. Enfield, J., Myers, R., Lara, M. & Frick, T. (2012). Innovation Diffusion: Assessment of Strategies within the Diffusion Simulation Game. *Simulation & Gaming, 43*(2), 188 - 214. doi:10.1177/1046878111408024 H

190. Thavikulwat, P. (2012). Life Span as the Measure of Performance and Learning in a Business Gaming Simulation. *Simulation & Gaming, 43*(2), 236 - 256. doi:10.1177/1046878110366001 H

191. Guderian, L. (2012). Music Improvisation and Composition in the General Music Curriculum. *General Music Today, 25*(3), 6 - 14. doi:10.1177/1048371311415404 S

192. Thompson, D. (2012). Music Technology and Musical Creativity: Making Connections. *General Music Today, 25*(3), 54 - 57. doi:10.1177/1048371311434639 H

193.	Yamaguchi, M. & Proctor, R. (2012). Multidimensional Vector Model of Stimulus-Response Compatibility. *Psychological Review, 119*(2), 272 - 303. doi:10.1037/a0026620	S
194.	Fluck, A., Ranmuthugala, D., Chin, C. & Penesis, I. (2012). Calculus in Elementary School: An Example of ICT-Based Curriculum Transformation. *Journal of Computers in Mathematics and Science Teaching, 31*(2), 159 - 174.	S
195.	Bolyard, J. & Moyer-Packenham, P. (2012). Making Sense of Integer Arithmetic: The Effect of Using Virtual Manipulatives on Students' Representational Fluency. *Journal of Computers in Mathematics and Science Teaching, 31*(2), 93 - 113.	S
196.	Bouck, E. (2012). Assistive Technology and Mathematics Education: Reports from the Field. *Journal of Computers in Mathematics and Science Teaching, 31*(2), 115 - 138.	H
197.	Fike, D., Fike, R. & Lucio, K. (2012). Does Clicker Technology Improve Student Learning? *Journal of Technology and Teacher Education, 20*(2), 113 - 126.	H
198.	Iserbyt, P., Mols, L., Elen, J. & Behets, D. (2012). Multimedia Design Principles in the Psychomotor Domain: The Effect of Multimedia and Spatial Contiguity on Students' Learning of Basic Life Support with Task Cards. *Journal of Educational Multimedia and Hypermedia, 21*(2), 111 - 125.	H
199.	Hathaway, D. & Norton, P. (2012). Video Production and Classroom Instruction: Bridging the Academies and the Realities of Practice in Teacher Education. *Journal of Technology and Teacher Education, 20*(2), 127 - 149.	S

Note. This table contains a sample of 199 peer-reviewed journal articles published in 2012 and indexed in the ERIC DB. I used the following search criteria on 2012-10-07: Thesaurus Descriptors: "Educational Technology" and Publication Type: "Journal Articles" and Peer Reviewed and Publication Date: 2012-2012. I reviewed the abstracts and descriptors for the first 200 returned articles (one duplicate was subsequently discarded). I searched for indicators of what each researcher means by the term “technology.” In reference to “technology,” the majority of researchers (>80%) refer to hard technology (material resources including computers and software). Soft technology (immaterial resources) is underrepresented in this sample. The final column in the table indicates the apparent technological focus:

- “H” represents an apparent “hard technology” focus, where the term “technology” appears to refer to hardware or software
- “S” represents an apparent “soft technology” focus, where the term “technology” appears to refer to theories, methods, or processes.

Author

Arun Lakhana is a professional software engineer, specialized in the development and management of information. He holds a Master's degree in Educational Technology. His research interests include systems theory, metacognition, and ambiguity. Email: arun.lakhana@gmail.com.