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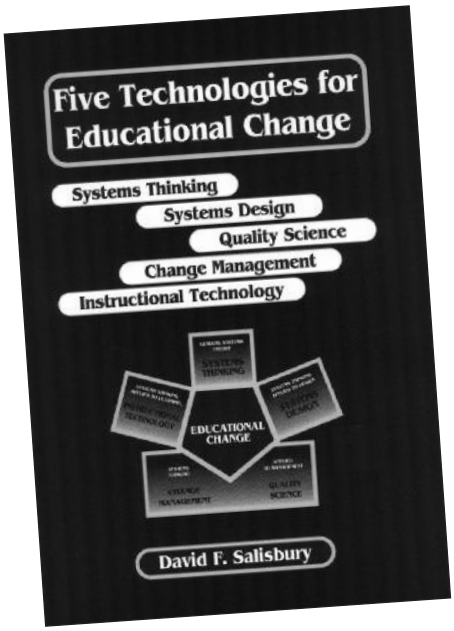
Five Technologies for Educational Change



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The Smart Classroom: Combining Smart Technologies with Advanced Pedagogies

Jungwoo Lee
Hyejung Lee
Yongki Park

Information and communications technology (ICT) is affecting every part of our society. Education is no exception, but here the impact of ICT is fragmented at best. The purpose of this article is to conceptualize and develop the idea of the *smart classroom* that integrates emerging information technologies with advanced pedagogies. System requirements for such a classroom are elicited from advanced pedagogical cases, and the system architecture is proposed based on the analyses of these requirements. The analyses are focused on pedagogies under development. Future applications of the proposed system are discussed.

Introduction

The development of information and communications technology (ICT) is bringing changes to every part of our society. The advancement of ICT is influencing the education sector, too (Kim *et al.*, 2011), where arguably the most prominent changes are the emergence and growth of e-learning. In overcoming the constraints of time and space, e-learning is evolving to provide a self-initiated learning environment allowing anyone to learn anytime and anywhere (Shin *et al.*, 2012). With the progress of ubiquitous technologies and the advancement of instructional practices, e-learning is evolving into *smart learning* (Noh *et al.*, 2011). The e-learning market in South Korea, for example, has achieved a robust expansion, having grown about 20 percent in 2011 alone (NIPA, 2012).

Despite the growth and evolution of e-learning, however, ICT has not yet brought remarkable changes to actual school settings. Although a variety of ICT tools have been made available in classrooms, the use of such tools has not stimulated innovative changes in teaching practices; rather, their use remains discrete and limited to augmenting pre-existing instructional approaches.

This situation suggests that there is a need to review smart learning in terms of the general education paradigm for the use of ICT. As shown in ***Figure 1***, smart learning is a new paradigm emerging from the convergence of advanced pedagogies with information and communications technology. With respect to ICT, there have been many conceptual variations of smart learning, such as e-learning, m-learning, and u-learning.

This article seeks to define a new classroom environment that is created through the convergence and combination of advanced pedagogies with smart ICT. We derive such a classroom's system architecture and functionality from an analysis of scenario-based requirements.

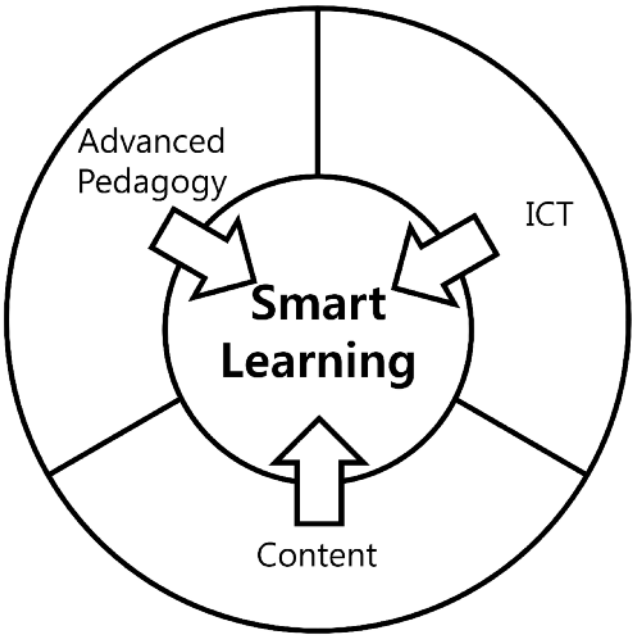

Figure 1. Components of Smart Learning.

Literature Review: Three Major Trends

Our literature review for the analysis of the smart classroom's system requirements focused on advanced

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pedagogies—advanced teaching and learning methods developed and promoted according to changes in the educational environment. Three major trends of smart pedagogies were selected and are discussed below: (1) student-centered learning, (2) cooperative learning, and (3) problem-based learning.

Student-Centered Learning

Until now, education has relied mainly on instructor-centered approaches, in which knowledge is delivered one-way from instructors to learners. The face of education, however, is changing. A typical example is the change from instructor-centered learning to student-centered learning. A primary feature of student-centered learning is constructivist learning. In constructivist learning, teachers are encouraged to help their students gain a better understanding of provided information and work out new ideas—or transform old ideas—using such information. Therefore, constructivist learning is learner-focused and learner-centered, with individual learners being viewed as constructors of knowledge (Park, 2001). Constructivist learning should involve six different factors: (1) a problem to be solved, (2) a related case, (3) a solution and relevant information, (4) a cognitive tool, (5) a conversation and cooperative system for exchange of information and ideas, and (6) a social/contextual support system (Jonassen, 1997; Noh *et al.*, 2011).

When organizing and conducting a class, the teacher should confirm how well the entire class is learning. This principle is associated with the argument that instructors should consider the learners' points of view when defining learning. Accordingly, attention should be given to how learners perceive educational content and how it should be applied. The dichotomous evaluation of "right" and "wrong" in conventional learning is no longer helpful to learners who pursue a wide range of values. Therefore, evaluations should be carried out between instructors and learners without reservations, and instructors should be able to identify the quantity and quality of their students' learning in a continuous manner (Park, 2001).

Consequently, a smart classroom system must be designed to enable bidirectional learning involving organic communication between instructors and learners, rather than one-sided teaching.

Cooperative Learning

Cooperative learning is an instructional approach in which learners work together in small groups to achieve shared learning goals (Johnson *et al.*, 1988). This approach invites group members to reach outcomes by setting and working towards a common goal, and it puts emphasis on cooperative evaluation of these outcomes. While learners are all on an equal footing, great emphasis is placed on the responsibility of individuals. Produced results should be beneficial to all members of the group, and group members are encouraged to take collective responsibility for the results. These features differentiate cooperative learning from other common instructional practices (Johnson & Johnson, 1990).

Cooperative learning is also distinguished from collaborative learning. In cooperative learning, the relationship between learners in a group is horizontal in nature, while collaborative learning is based on vertical relationships among learners. More specifically, members of a cooperative learning group work together towards a common goal, whereas collaborative learning encourages students to help one another in the process of pursuing their respective individual goals (An & Baek, 2011).

In cooperative learning, students learn in an interdependent manner, unlike in other general group activities. Interdependence means that the success of an individual is influenced by other people in the group. Thus, a learner's success has a positive effect on other group members, and his/her failure has a negative effect. As a consequence of positive interdependence, learners work hard to achieve group learning goals instead of their own personal goals, and they exhibit higher learning performance through interaction (Choi, 2006).

The smart classroom system should be organized in a way to foster active interactions among learners for cooperative learning and provide elements that allow instructors to facilitate this interaction.

Problem-Based Learning

Problem-based learning places emphasis on activities that involve understanding problems or finding solutions to them. This approach to learning starts with exploring learners' problems and identifying problems that need to be solved (Barrows, 1996). Problem-based learning encourages learners to apply their content knowledge, critical thinking, and problem-solving skills to real-world problems and issues (Levin, 2001). Learners are invited to acquire necessary knowledge themselves through the problem-solving process, beginning with real, unstructured problems. Problem-based learning encourages learners to develop an interest in learning by connecting acquired knowledge to real-world activities, and it helps them develop the ability and initiative to solve problems they may actually face.

Problem-based learning is implemented with a focus on situation-specific problems that are directly related to learners' real lives and concerns. Learners generalize their own experiences while solving such problems (Baek & An, 2011). Problem-based learning emphasizes that learning takes place in the process of solving problems; not by memorizing content but rather by taking advantage of cooperation and collaboration with colleagues and classmates. The role of instructors is also different from conventional instructional approaches, in which instructors deliver knowledge to learners in a unidirectional manner and only evaluate the outcome. In student-

centered learning, in contrast, learners acquire methods of taking advantage of knowledge through group activities, and they evaluate themselves or are evaluated by their instructors and fellow learners (Barrows, 1996).

The process of problem-based learning is divided into two phases: the design phase of developing problems and the implementation phase of planning, implementing, and evaluating an actual teaching-learning process (Trop & Sage, 1998). The problem design that is prepared by an instructor before class takes the form of a scenario that reflects learning content. In designing a problem, problem-based learning requires a working-through process that can sustain the attention of learners, who should be able to grasp the goal and core educational content. Learners should clearly understand their roles, what they know, and what they need to know.

Given that problem-based learning is made possible by student-centered learning and cooperative learning, the smart classroom system should support learner–learner and learner–instructor interactions for problem-based learning to be successful. In addition, the system needs to allow relevant problems to be provided and authored on a situation-specific basis.

Analysis of Smart Classroom System Requirements

As the first step in analyzing a smart classroom's system requirements, we collected and analyzed teaching–learning scenarios about the three advanced-pedagogy trends discussed above. The analysis was conducted with the three scenarios of highest relevance, selected from a total of 24 scenarios, after eliminating overlapping scenarios or those that were only marginally relevant.

Scenarios

For the analysis of requirements, we analyzed three scenarios: student-centered learning, cooperative learning, and problem-based learning. From these scenarios, we drew some keywords which were necessary for the smart classroom system. These keywords are references in the modeling and used to derive requirements.

Scenario 1: Student-centered learning

Before class, learners use the smart learning system to check the information they learned yesterday. On a self-diagnosis page, they give an evaluation of themselves and set and enter the day's learning goal. When the "Send" button is pressed after the input is completed, a message is sent to the instructor.

Before class, the instructor reviews the learners' information about learning history and the day's learning goal. While doing so, the instructor writes down information useful for learners or his/her comments on the learning progress. He/she then transmits his/her input to the learners so they are informed before attending the class.

After the class, the instructor presses the "End Class" button on the smart device. He/she evaluates the learning content of each learner and monitors their progress. Subsequently, the system closes sensors at work and saves information about the day's lecture, team activities, and evaluations.

The main keywords derived from student-centered learning scenario are "self-diagnosis page," "evaluation of oneself," "learning history," "today's learning goal," and "instructor's comments"

Scenario 2: Cooperative learning

Cooperative learning is a task requiring teamwork, so the instructor presses the Create Member button on the instructors-only interface. The smart learning system begins to divide learners into teams based on the day's rollbook. Once teams are organized, the team-building information is made available on each learner's smart device and also via a projector. The system creates a team session for learners to exercise effective teamwork. Learners work through the team session and then request permission from the instructor to make a presentation. The instructor approves the presentation, and the smart learning system tracks the team's location and pans a video camera towards the location. The projector projects the presentation team so that all learners can watch the presentation.

After the presentation, learners input other teams' evaluations into their smart devices, and the instructor evaluates the presentation by means of his/her own smart device. The evaluation information is automatically gathered by the system and transmitted to members of the presentation team.

The main keywords derived from the cooperative learning scenario are "team member creation," "team building information," "team session creation," and "team location tracking."

Scenario 3: Problem-based learning

The instructor checks attendance information before starting the day's class. He/she imports from his/her smart device a variety of multimedia-based learning aids to be used in class, including videos, pictures, and audio materials. The smart learning system automatically displays class materials on the projector as well as on each learner's smart device. When the instructor starts the class, the smart learning system detects his/her movements and projects these onto the video camera to display the images on the projector. Learners raise their hands in class to ask questions. The positioning sensor detects their hand-raising gestures and projects the learners onto the video camera to show the images through the projector. Even if it is difficult to see the faces of questioners at a distance, the instructor answers their questions while looking at them through his/her personal device where the images of learners are displayed.

In setting the day's problem-based learning questions,

Table 1. Keywords derived from learning scenarios.

Scenario	Keywords
Student-Centered Learning	– Self-diagnosis page – Evaluation of oneself – Learning history – Today's learning goal – Instructor's comments
Cooperative Learning	– Team member creation – Team building information – Team session creation – Team location tracking
Problem-Based Learning	– Automatic display of class materials on the project – Display of class materials on personal smart devices – Detection of the instructor's movements – Sensor detection of learners' gestures – Extraction of data from the problem bank

the instructor extracts data from the smart learning system's problem bank and transmits them to the learners. The learners retrieve additional data with their smart devices based on the data received from the instructor and work through the instructor's questions. They write answers to given questions with their smart devices and send them back to the instructor. Their solutions are also displayed on the projector screen so other learners can view them on the smart learning system. The instructor corrects and explains the problems with answer sheets using a pen mouse on his/her personal smart device. Then he/she sends an answer-explanation sheet with instructions to the learners.

The main keywords derived from the problem-based learning scenario include "automatic display of class materials on the project," "display of class materials on personal smart devices," "detection of the instructor's movements," "sensor detection of learners' gestures," and "extraction of data from the problem bank." These keywords are listed in ***Table 1*** along with the keywords derived from the two other scenarios stated above.

Using the Unified Modeling Language (UML)

Modeling a smart learning environment requires a high-level modeling approach for the exchange of data and control information between modules and collaborative work between modules. We have adopted the Unified Modeling Language (UML) notation for object-oriented modeling to create smart learning scenarios by modeling a smart learning system. Keywords identified in scenarios are used as the basis for modeling.

Studies of object-oriented modeling began in the 1980s, and in 1996 UML, which evolved from the integration of different modeling techniques, was accepted as a standard modeling language by the Object Management Group (OMG). UML, a third-generation modeling language that helps describe object-oriented metamodels strictly, has been useful in elucidating the structure and behavior of objects. Typically, object-oriented modeling is applied during the early design stages and completed before implementation, but recently it has been used widely in analyses for improving the reliability of completed systems because of its capability to integrate the systems' structural and operational characteristics.

UML consists of 13 types of diagrams, divided into three categories:

- ***Behavior diagrams*** represent the behavioral aspect of system or business processes and include activity and state machines; they use case diagrams and interaction diagrams.
- ***Interaction diagrams,*** a subset of behavior diagrams, emphasize the interactive operation among objects and include communication, interaction overview, sequence, and timing diagrams.
- ***Structure diagrams*** describe the components of a system or business process, regardless of time, and include class, composite structure, component, deployment, object, and package diagrams.

Model-based development techniques using UML aim to develop software that is executable independently of the design environment or hardware system. They automatically transform human-created independent models into platform-dependent executable code. This enables an application or behavior to be defined without being affected by hardware characteristics or developer preferences, and thus there is no need to create models repeatedly when the system is modified later.

The focus of our study is on how users make use of the system in a smart learning environment. In order to create this in UML, we adopted two different diagrams: the use case diagram as a behavior diagram depicting user-system interactions, and the class diagram as a structure diagram representing the system's architecture. The adopted diagrams were used to analyze system requirements. The *use case* and *class diagrams* are illustrated in ***Figure 2*** and ***Figure 3***.

Functional Requirements

We derived several functional requirements using UML based on the keywords and scenarios identified above. The five derived functional requirements are to support diverse multimedia interactions, support diverse teaching-learning environments, ensure compatibility between various kinds of equipment, provide easy-to-use interfaces, and allow instructors to control learning.

First, regarding diverse multimedia interactions, the system should support features that enable interactions between instructors and learners in three-dimensional

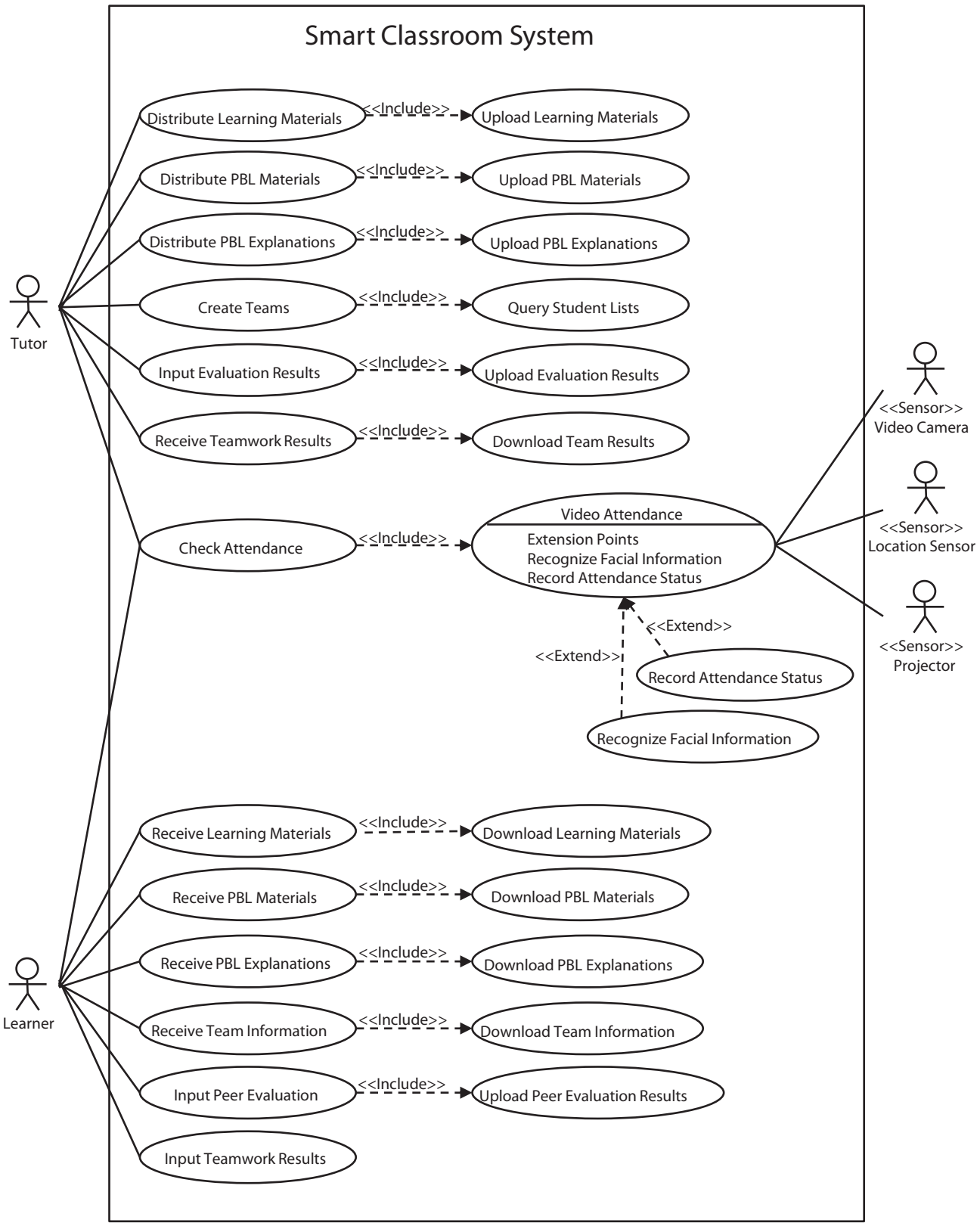

Figure 2. Use Case Diagram of Smart Classroom.

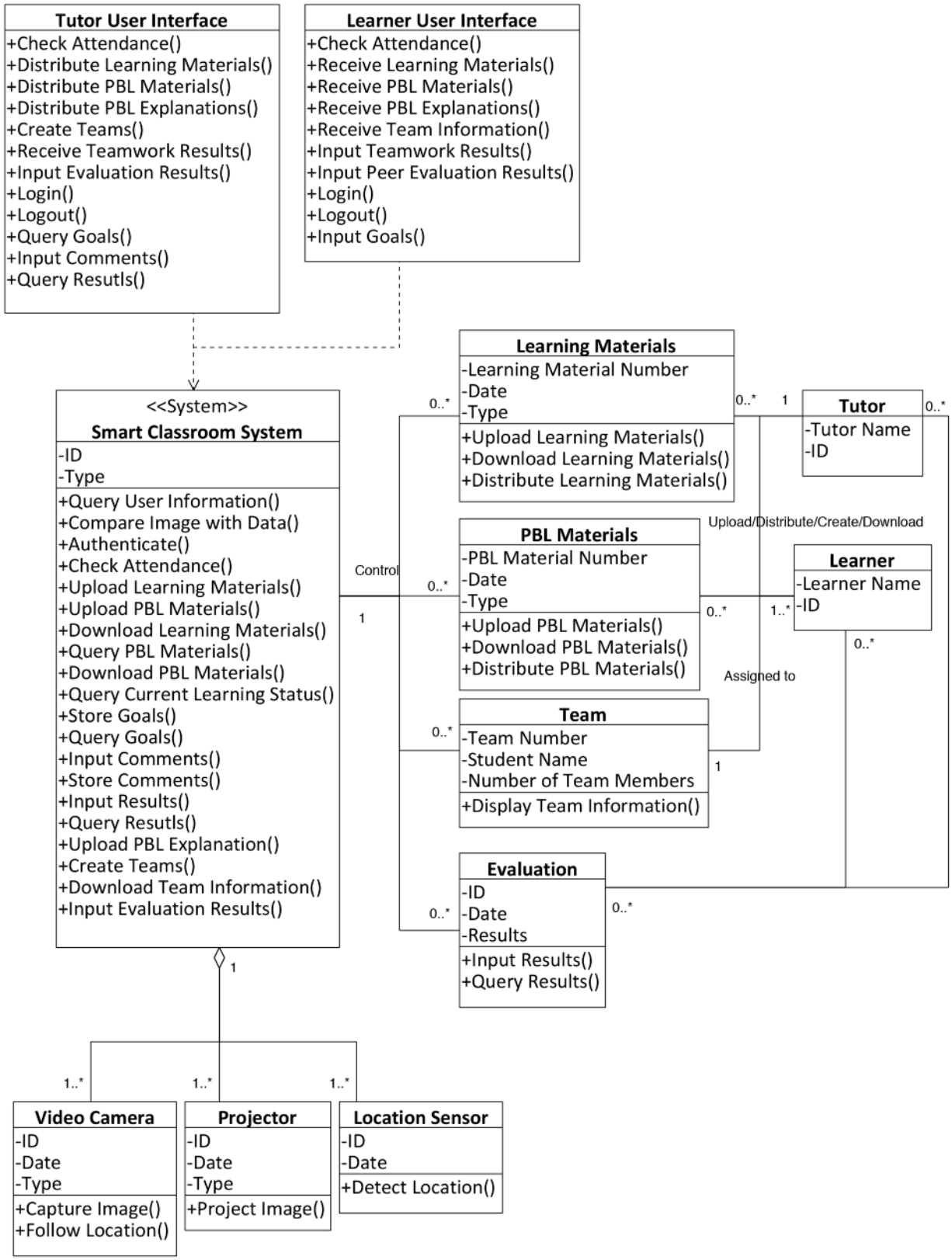

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Figure 3. Class Diagram of Smart Classroom.

spaces, beyond just watching two-dimensional video. Multimedia should also support interactions that accommodate different types of pedagogical actions, taking relative positions of instructors and students into consideration.

Second, an educational environment should be flexible enough for diverse pedagogies to be used. It should also be an intelligent environment, where smart pedagogies are made available in tandem with unidirectional, teacher-centered learning. Student-centered learning should also take place, with the encouragement and monitoring of personalized and competence-based learning. In particular, the educational environment should create instructional settings where students discuss learned content among themselves, using an easy-to-control system.

Third, a smart classroom should support various kinds of equipment that can be used in combination, and their compatibility should be ensured in the learning and communication processes. Existing classroom settings are typically furnished with equipment that was adopted as new information technology became available, but such classrooms usually have multiple devices with different interfaces. Even though the smart classroom may also have different interfaces for its equipment, it should have a system in place to organize an integrated and convergent environment, where the equipment can be controlled and run in an intelligent and flexible way.

Fourth, easy-to-use interfaces and simple features should be available in class. The classroom environment should enable instructors to perform different forms of pedagogy through using intuitive and simple interfaces that do not require skill in program installations or system operations. A teacher should be allowed to control the system by simply pressing a button, and such system operations should not interrupt the lecture or students' learning.

The fifth functional requirement is that instructors should be able to control the learning situation. A student that is learning based on his/her individual level should be allowed to identify his/her personal learning progress to prevent concentration from falling off. During problem-based learning, students should be able to view other students on a screen or conduct group activities through simple operations. In this way, the instructor should have the ability to control multiple levels of interactions.

Technical Requirements

We also derived five technical requirements based on the functional requirements. They are "content authoring," "T-learning system," "edutainment system," "video conference system," and "camera tracking system."

First, techniques for authoring diverse content are required to support a wide range of pedagogies. Content authoring techniques can be classified as production techniques, management techniques, and evaluation techniques. Learning content includes any and all multimedia data currently available. To create each piece of learning content, there should be an authoring tool tailored to the purpose; learning content in the manual format is mainly made up of images and text. Content management techniques refer to the types of techniques that are used to retrieve, store, and deliver authored content after publication. Content evaluation techniques, which are unique to e-learning content, are used to evaluate the content used in education and reflect the evaluation results.

Second, a television-based or T-learning system should be supported. Because learner-centered classes are planned and taught according to the competence levels and progress of learners, student-centered learning can produce differences among students in the same class. T-learning helps students learn in ways that are tailored to their levels of competence. In the past, T-learning was instructor-led and unidirectional, but now more advanced bidirectional learning has been enabled as digital broadcasting and IP-TV services have emerged with the progress of ICT.

Third, in a smart learning environment, students' engagement in learning can decrease. Therefore, there is a need to increase their interest in learning. The edutainment system is an effective way to foster learners' interest in class work. Characterized as a combination of entertainment and education, the edutainment system arouses students' interest in learning through games and enhances their understanding of learned material by encouraging them to stay engaged in learning.

Fourth, a video conference system should be supported with a variety of multimedia. The video conference system allows participants to communicate multimedia information such as videos, voice, text, and graphics in real-time via a network that connects two or more locations, as if a meeting were taking place at the same time and place. Accordingly, when it is used as a learning system, real-time education can be delivered regardless of geographic distance, and there is the additional advantage of an instructor's direct guidance. Like conference chairs, instructors will be able to lead students easily through the learning process.

Fifth, a camera tracking system should be constructed to facilitate organic interactions among learners or between instructors and learners. The camera tracking system, which is mainly used in school lecture rooms or corporate training rooms, allows the camera to track an instructor or student automatically, without user intervention.

Figure 4 shows the schematic relationship between the functional requirements derived from the scenarios and the technical requirements as ways to meet the functional requirements.

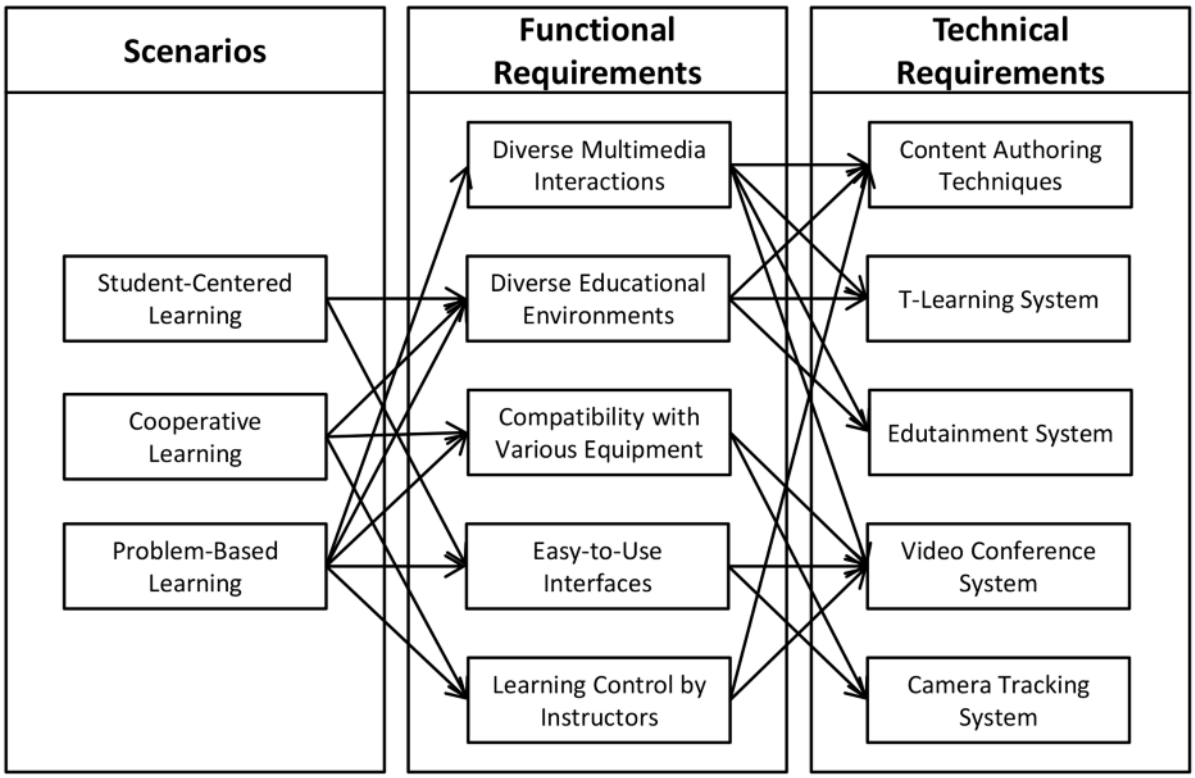

Figure 4. Schematic relationship of requirements for Smart Classroom System.

The System Architecture

Under the influence of information technology, school classrooms are now furnished with a variety of information and communication devices. Most of these devices, however, are developed discretely for use in different settings and thus lack any connection to one another. This makes it difficult to apply them in advanced, smart classrooms. Moreover, existing classroom systems have failed to manage various kinds of equipment in an integrated manner. Multiple devices have separate connections for different management systems and, in most cases, can be accessed only by instructors.

These systems can be improved by meeting the requirements derived from the analysis of the scenarios discussed above. The improved systems provide a single integrated user interface for "smart" teaching-learning methods and, accordingly, ensure consistency, convenience, and better performance for use in classrooms. In addition, operations are simplified so as to minimize distractions in class. Learners can use learning devices easily through simple operations, and the devices can be immediately applicable in classroom environments because instructors and learners do not need further training or special skills.

A smart classroom system provides a consistent user interface and thus is very easy to use. Cables with separate connections to different devices can be managed conveniently when they are connected to an integrated smart classroom system. Instructors and learners can use a variety of multimedia tools, including computers, VTRs, DVDs, mobile devices, and cameras, and the system can be conveniently maintained and managed through the integration of software applications and devices. As learners' PCs are connected to the smart learning system through a network hub, instructors can transmit data to learners, switch pages on their screens, or send a learner's page to other learners. ***Figure 5*** shows the architecture of such a smart classroom system.

In our study, the system architecture was organized into three layers: controller layer, middleware layer, and database layer. The controller layer consists of terminal connection, information gathering, service management, and utility controllers. The middleware layer is represented by context control and communications middleware. The database layer includes three databases: the user database, content database, and context information database.

The controller layer helps build connections between users and devices or between individual devices. The terminal connection controller enables learners to connect and use their terminal equipment, such as PCs, smartphones, or laptops, for learning purposes. The information-gathering controller allows learners to use information input devices, such as cameras, camcorders,

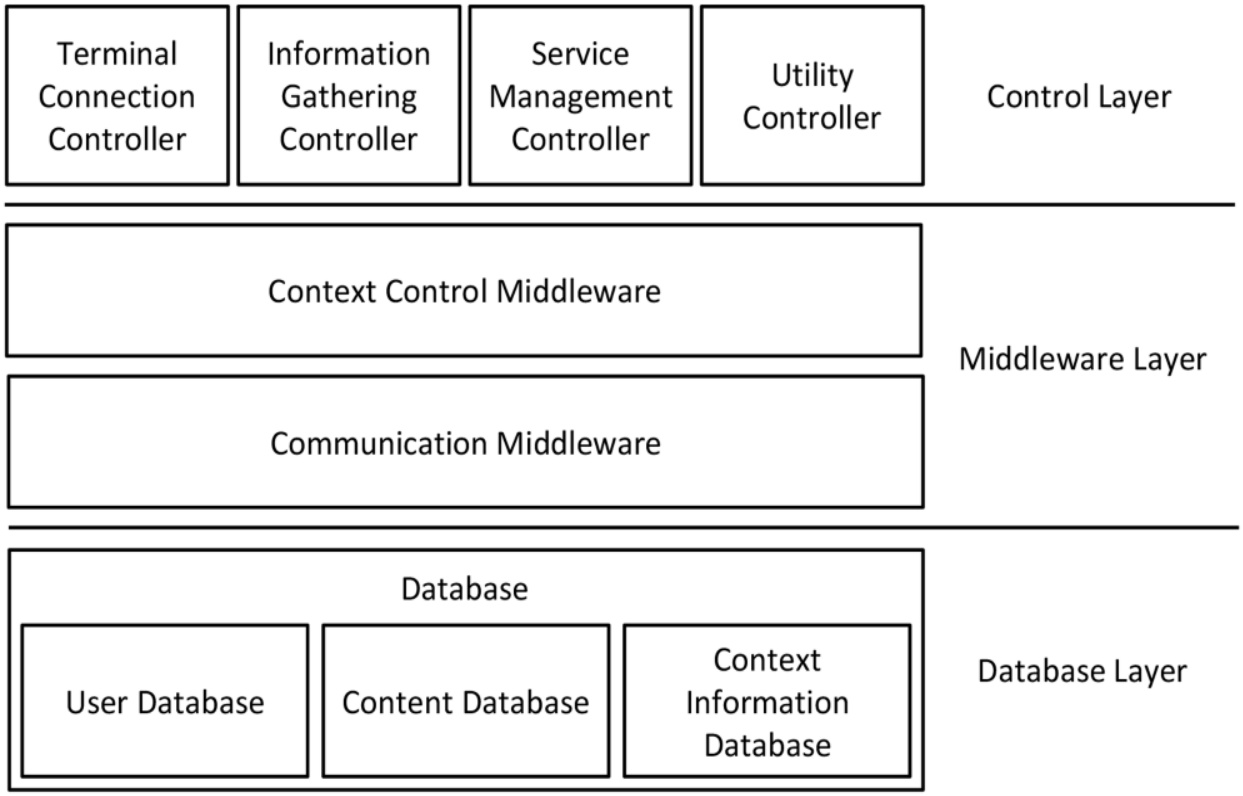

Figure 5. Architecture of a Smart Classroom System.

and video presenters. The service management controller helps instructors to control the overall instructional content and process. The utility controller, meanwhile, works to facilitate the use and control of other devices.

Middleware enables communication to occur between the controller layer and database layer and the system's data processing. The context control middleware analyzes events occurring in the controller layer and processes them in a dictionary-defined way. The communication middleware contributes to facilitating the communication between interfaces.

The database layer plays the role of storing learned information. The user database integrates and stores learners' basic information about learning conditions, learning progress, and competence levels. The content database stores the content necessary for learning, and the context information database stores information related to the processing of events used by the context control middleware.

Conclusion

The smart classroom system can be used for a wide variety of purposes, especially in areas where future-oriented, convergent education is needed. While contemporary pedagogies have moved away from instructor-led approaches, the availability of ICT in education—namely, e-learning, m-learning, or u-learning—is leading the way toward acceptance of a convergent educational model; this is occurring in tandem with the generalization and public consumption of knowledge from the Internet. The smart classroom system proposed in this article will be available immediately in group classrooms, digital conference rooms, multimedia rooms, and medical laboratories. We expect that ICT will first be made available in group classroom activities that use a wide variety of multimedia tools and a wealth of data. Educational environments suitable for cooperative learning or problem-based learning will increase learners' creativity and cooperativeness and help them to further concentrate on learning.

In state-of-the-art digital conference rooms equipped with a smart classroom system, meetings can be organized and conducted in a rapid, exact, and convenient manner, and information can be communicated more clearly through real-time, on-screen transmission; this will also allow additional description of materials without the need to distribute handouts in advance or rearrange seats.

When used in a multimedia room, the smart classroom system helps learners improve their understanding of lessons by allowing them to use a wealth of multimedia materials. As an optimal learning environment is created by the use of diverse multimedia equipment, the smart classroom system promotes learners' concentration and engagement in class.

Medical laboratories used in the training of physicians are one of the environments where information technologies should be dynamically employed. For example, a bidirectional image transmission system makes preclinical medical training more effective when it is used to transmit real-time images of an instructor's operative demonstrations to learners. □

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Addressing STEM Education Needs: The Case for Adopting a PBL Approach

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STEM (science, technology, engineering, and math) disciplines are considered key to the scientific and economic improvement in the United States. As noted by the Carnegie Corporation of New York (2011), we need a nation in which *all* teachers and thus, all students, are "STEM-capable" (p. 2), that is, equipped with a broad foundation of STEM knowledge as well as a set of crucial skills needed to achieve rigorous STEM learning. Unfortunately, current STEM education in the U.S. fails to provide students with opportunities to *experience* how science, technology, engineering, and math are conducted in the real world. Problem-based learning (PBL), as a student-centered curricular method, has significant potential for engaging students in authentic STEM content through the active pursuit of workable solutions to real-world problems. In this article, the authors describe benefits and challenges to adopting a PBL approach in both teacher preparation programs and K–12 STEM education.

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Introduction

In the last few decades, the world has seen tremendous change. For the first time in history, yearly spending on information and communications technologies (such as computers and cell phones) has surpassed yearly spending on industrial technologies (such as assembly lines; Trilling & Fadel, 2009). As a result of this shift from the industrial to the knowledge age, an increasing number of manual labor jobs have been subsumed by technology or automation, leading to a greater need for human workers to possess critical thinking and problem-solving skills. However, as Kay (2010) noted, even if today's high school students mastered traditional subjects such as language, math, and science before receiving their diplomas, "[students] would *still* be ill prepared" for the demands of today's workforce (p. xviii). Furthermore, this issue does not apply solely to secondary schools, as students graduating from technical colleges and universities also have been described as lacking key skills in the areas of communication, critical thinking, problem solving, collaboration, working on diverse teams, and applying technology (Trilling & Fadel, 2009).

In an effort to meet the challenge of preparing students for both higher education and the workplace, curricular changes have already been implemented in today's schools. For example, many states are now requiring high school students to complete up to three years of math and science in order to earn their diplomas (*Education Week*, 2008). In addition, across the curriculum, students have been given increased access to digital resources, opening the door to a world of information and communication beyond the confines of their schools or classrooms (Trilling & Fadel, 2009). Though these changes are a step in the right direction, Kuenzi (2008) stated, "the math and science achievement of U.S. pupils and the rate of STEM degree attainment appear inconsistent with a nation considered the world leader in scientific innovation."

Importance of STEM

STEM (science, technology, engineering, and math) disciplines are considered key to the scientific and economic improvement of the nation. For example, in 2009, President Obama issued a "call to action" for improving STEM education as a national priority to spur efforts of innovation, creativity, and future job development (Office of the Press Secretary, 2010). Eberle (2010), executive director of the National Science Teachers Association, described the importance of science as "the one subject that encompasses everything in life and helps students be curious, ask questions, and make connections as to why the world exists as it does" (p. 62). However, these statements are in contrast to current classroom practice, which is designed primarily to address accountability standards, especially given the punitive consequences imposed on those who fail to meet them (Demarest, 2010; Guisbond & Neill, 2004; Orlich, 2004). As the National Research Council (NRC, 2012) stated, a standards-based approach, "neglects the need for students to develop an understanding of the practices of science and engineering, which is as important to understanding science as knowledge of its content" (p. 10).

While policy may be a starting point, in order to enact that policy, students need access to competent teachers who can design high-quality lessons that engage them in the application of relevant STEM skills (Weiss, Pasley, Smith, Banilower, & Heck, 2003). Crawford, Zembal-Saul, Munford, and Friedrichsen (2005) described a disconnect between many low-level, lecture-based pre-service science education programs and the expectation that these future teachers will facilitate higher-order thinking and inquiry among their own students (National Research Council, 1996). Sadly, this disconnect gets passed down from teacher education programs to the K–12 schools. As noted by the NRC (2012), "K–12 science education in the United States…emphasizes discrete facts with a focus on breadth over depth, and does not provide students with engaging opportunities to experience how science is actually done" (p. 1). As such, students graduating from U.S. high schools may be able to recite a wide range of scientific facts (although that, too, is debatable), but have little to no idea what it means to be a scientist. As illustrated by results of the National Assessment of Educational Progress (NAEP, 2011), only 32% of 8th grade students in the U. S. achieved "proficiency" in science by demonstrating competency when presented with challenging subject matter.

Though the National Research Council is specifically concerned with science education, the emphasis on facts over inquiry is a practice that is recommended across STEM disciplines. For example, Ernest (1994) noted that the emphasis on discovery learning in mathematics started as far back as the 1960s, though "discovery" tended to be practiced in only a "carefully arranged and orchestrated corner of the world" (p. 1). According to Sigel and Borasi (1994):

> Mathematics textbooks, pedagogical practices, and patterns of classroom discourse, especially, work in concert to perpetuate the idea that mathematics is the 'discipline of certainty.' Together with a behaviorist view of learning, this myth has led students and teachers alike to reduce mathematical learning to the acquisition of ready-made algorithms and proofs through listening, memorizing, and practicing. However comfortable these myths may be, they have debilitating consequences for students (p. 201).

From Siegel and Borasi's perspective, not only does a rote approach to mathematics give students a false, black-and-white picture of its place in the world, but it

also conditions students to expect certainty in their schoolwork and thus, to feel uncomfortable with the uncertainty that inquiry-based approaches provide.

Addressing similar concerns, engineering educators have also been looking for ways to enable students to master not only basic technical skills, but also skills related to inquiry, problem solving, communication, collaboration, and self-directed learning. Although technical knowledge and skills still make up the bulk of current engineering curricula (Trevelyan, 2008), this has begun to change as industry has started to demand a new type of engineer (Duderstadt, 2008).

While many theorists, educators, and politicians agree that it is important to emphasize STEM education and 21st century skills, such as inquiry and problem solving, this emphasis is not yet apparent in the majority of teachers' classrooms. In an NSF-sponsored study of 364 K–12 math and science lessons, Weiss *et al.* (2003) concluded, "the nation is very far from the ideal of providing high quality mathematics and science education for all students" (p. 104). According to the researchers, most of the observed math and science lessons failed to do one or all of the following: "engage students with the mathematics/science content; create an environment conducive to learning; ensure that all students have access to the lesson; and help students make sense of the mathematics/science content" (p. xi). In their study, Weiss *et al.* also noted that while teachers are often specifically told *what* they need to teach, they are usually given quite a bit of leeway regarding *how* they teach. This flexibility may be key to improving STEM education.

Problem-based Learning

Though there is no single pedagogy that will meet all the needs of 21st century learners, many of the deficiencies described in STEM education could be addressed using a problem-based learning (PBL) approach. This type of instruction, initiated in medical schools as a way to provide a student-centered (Neufeld & Barrows, 1974), practical approach to identifying and solving complex, real-world problems, has become an accepted instructional method in both higher education and K–12 classrooms (Levin, 2001; Savery, 2006; Torp & Sage, 2002). PBL is based on the assumption that engagement in meaningful problem solving facilitates students' mastery of subject matter, as well as the development of their higher-order thinking skills (Hmelo-Silver, 2004; Jonassen, 2011). According to Kostelny DeRoche (2006), there are many varied reasons for adopting PBL. In her school, specifically, PBL was used to:

> facilitate differentiation; it was motivational, meaningful, and collaborative; it was constructivist, yet pragmatic; it would place the responsibility of the work of learning on the students rather than on the teachers; and it would afford students active involvement and a degree of control and choice in their own learning. Finally, and perhaps most important, it would not add to the curriculum already in place but would simply approach it in a different way (p. 706).

In terms of addressing 21st century skills, a PBL approach would encompass all of the recommended skill sets, including critical thinking, collaboration, self-direction, and accountability (Kay, 2010). In addition, many of the positive characteristics that Kostelny DeRoche attributes to PBL directly address the attributes that Weiss *et al.* (2003) assigned to high-quality math and science lessons. Specifically related to engineering, PBL also seems to be a valid approach, as "a good engineer is able to identify and define a problem and to find a working solution to this problem" (Costa, Honkala, & Lehtovuori, 2007, p. 41).

Because PBL incorporates authentic problems situated in realistic settings, it readily aligns with the constructivist theoretical perspective. Brown, Collins, and Duguid (1989) introduced the terms "situated cognition" and "cognitive apprenticeship" to highlight how learning is linked with context. Both of these terms relate to "supporting learning in a domain by helping students to acquire, develop, and use cognitive tools in authentic domain activity" (p. 39). The emphasis on cognition is meant to underline that both knowledge and skills are built upon cognitive processes, which an instructor facilitates by engaging students in new and different learning roles, through the help of scaffolding. In this way, students learn to *produce* knowledge rather than simply consume it (Siegel & Borasi, 1994).

The PBL Process: Planning, Facilitating, and Debriefing

Facilitating a PBL unit effectively is dependent on thorough planning, careful guidance of students during the experience, and constructive debriefing afterward (Savery, 2006). Thus, to be successful, teachers must be able to understand and enact these different roles.

Planning PBL instruction is not easy, and as Ertmer *et al.* (2009) found with middle school teachers who were new to implementing PBL, it is quite possible to be overwhelmed by the amount of preparation required. These teachers described planning as including: choosing a good driving question, anticipating student questions and needs during the unit, making decisions about the best way to group students, and collecting adequate and appropriate resources. In addition to these preparation concerns, Thomas and Mergendoller (2000) found that experienced PBL teachers also emphasized scheduling in their planning in order to adjust for student performance, unforeseen delays, and even to ensure that due dates for major papers and projects

did not occur simultaneously.

During implementation, the teacher is expected to actively guide student progress, manage groups, and provide constant feedback during class time (Ertmer & Simons, 2006). Ertmer and Simons stressed the idea of scaffolding as key to successful implementation of a PBL unit, noting that scaffolds can be used to accomplish four important goals:

(1) initiate students' inquiry
(2) maintain students' engagement
(3) aid learners with concept integration and address misconceptions
(4) promote reflective thinking (p. 45)

Within constructivist environments such as those used for PBL, scaffolds are seen as a way to help students cope with the ill-structured nature of the environment. Putambekar and Kolodner (2005) identified five features that are common to scaffolded instruction: common goals, ongoing diagnosis, dynamic and adaptive support, dialogue and interaction, and final fading of the scaffolding. Because these five features can be both individual and time sensitive during the learning experience, their research with middle school science students indicated that multiple varieties, of sometimes redundant scaffolding tools and agents, working in conjunction, offered learners the best opportunity to succeed with an ill-structured task.

In discussing multiple scaffolds within a multimedia learning environment, Saye and Brush (2002, 2004) differentiated between "hard" and "soft" scaffolds. Hard scaffolds are defined as those that are created ahead of time to aid learners in specific areas of concern or difficulty. Conversely, soft scaffolds are defined as just-in-time, flexible supports that are employed as learners encounter difficulties along their paths of inquiry or exploration. These soft scaffolds generally fall within the dynamic and adaptive support, ongoing diagnosis, and dialogue/interaction types of scaffolds described by Putambekar and Kolodner (2005). As such, they require an adept and observant instructor with a complex grasp of the environment and desired performance (Saye & Brush, 2002, 2004). Regardless of the type of scaffolding used, scaffolds are considered a necessary component of PBL in order to support students' efforts with collaboration, problem-solving, and self-directed learning (Savery, 2006).

Role of the PBL Teacher

The adoption and implementation of PBL has been observed to challenge conventional, familiar, and habitual roles exercised by traditional educators and their discipline-specific teaching practices (Murray & Summerlee, 2007). As such, the adoption of PBL necessitates a new way of conceptualizing teaching and learning. As Kolmos (2006) stated, the most important aspect of adopting a PBL approach is "the shift from teaching to learning" (p. 40). Consequently, the role of the teacher changes from an emphasis on transferring knowledge to one focused on facilitating learning.

Due to its constructivist nature, not all teachers will feel comfortable implementing PBL in their classrooms (Mergendoller, Maxwell, & Bellisimo, 2006). If a teacher believes his/her primary role is to transmit information, PBL may be used improperly as a motivational activity rather than a student-centered approach to facilitate desired learning outcomes (Trigwell & Prosser, 1996). Even if a PBL unit is properly aligned with content standards, the shift in roles and responsibility can result in instructor uncertainty about his/her place in a student-centered classroom. Teachers have expressed several fears stemming from the reduction or elimination of direct instruction, including that their content expertise may not be utilized or that their students may not cover all the standards-based concepts they are required to learn (Dahlgren, Castensson, & Dahlgren, 1998; Lehman, George, Buchanan, & Rush, 2006).

While it is the teacher's job to provide various types of scaffolding throughout the implementation of a PBL unit, it is also important that the teacher not cross the line from facilitator to content expert. Instead of dispensing content or clearing up the messiness of the problem at hand, the teacher is expected to model questioning and reflective practices so that students can internalize those processes, and thus allowing these external supports to be faded as the students become more independent. Hmelo-Silver and Barrows (2006) identified key questioning practices by an expert facilitator, such as pushing students for explanations, restating group ideas as clarifying questions, asking quiet students to summarize, encouraging students to generate hypotheses, then asking students to evaluate hypotheses. Jonassen (2011) noted that students cannot learn problem-solving by learning *about* problem-solving, so it is important that the facilitator allow students to engage with problems on their own and to make mistakes. This can be hard for teachers, especially those new to using PBL, as it is easy to fall back into old teaching habits and to "scaffold" the open-endedness of a PBL unit to such an extent that the activities become prescribed and the outcomes predictable (Goodnough, 2005).

Role of the PBL Student

When a student-centered approach, such as PBL, is implemented, students who are unfamiliar with the approach may struggle or even reject the approach completely (Felder & Brent, 1996). Simply providing an engaging question along with scaffolds may not sufficiently orient students to the new expectations of a PBL approach. As Jonassen (2011) stated, "we cannot assume that learners are naturally skilled in problem solving, especially complex and ill-structured problems

such as those required in most PBL programs" (p. 96). Dabbagh and Williams Blijd (2010) found that even their first-semester graduate students had issues dealing with the "ambiguity and complexity" of the problems they were presented (p. 15).

Besides issues with problem solving, past educational experiences have conditioned students to expect courses to run a certain way (Dean, 1999). Henry, Tawfik, Jonassen, Windholtz, and Khanna (2012) reported that the participants in their study (i.e., undergraduate engineering students in a materials science course) expected relevant content to be covered in lecture *before* attempting to tackle a problem. When, instead, the lecture came *after* the problem was introduced, students expressed frustration with the process. Dabbagh and Williams Blijd (2010) also noted student ill-preparedness when it came to accepting responsibility for organizing and constructing knowledge.

Once students buy into the concept, however, PBL can afford them benefits that are otherwise unavailable in traditional classrooms, such as being able to spend more time on topics of interest, particularly within the domain of relevant content (Ferreira & Trudel, 2012; Mergendoller *et al.*, 2006). With interest and relevance aligned with content, PBL students tend to adopt deeper approaches to studying (Prosser, 2004). According to a recent meta-synthesis of existing meta-analytic reviews (Strobel & van Barneveld, 2009), students who learned via a PBL approach retained what they learned longer than those who did not learn via PBL. Furthermore, as the assessment focus shifted from knowledge and facts to more complex forms of reasoning, PBL students tended to outperform their non-PBL peers.

In order for students to be successful with PBL, they not only have to assume a more active role in their learning, but also they must be able to work in collaborative groups (Ferreira & Trudel, 2012; Savery, 2006). Especially with heterogeneous groups, difficulties may arise in integrating perspectives from members who have varying levels of expertise and experiences (Dabbagh & Williams Blijd, 2010). In order for learning to occur, however, students must overcome these difficulties and use their group time to verbalize ideas collected from individual study (Yew & Schmidt, 2012). While students in groups can learn from each other, Dean (1999) noted that facilitation is still very important to this process as, without proper guidance, student groups tend to discover only surface level information instead of probing beyond the superficial.

Teacher STEM Education and Professional Development

Evidence shows that PBL can help both pre-service (Park & Ertmer, 2007) and in-service teachers (Derry, Siegel, Stampen, & the STEP research group, 2002) change their ideas about how to structure instruction in their current and future classrooms. Additionally, engaging pre- and in-service teachers in professional development experiences that integrate STEM content with PBL methods has the potential to simultaneously increase teachers' knowledge of both STEM content and PBL (Ertmer, 2012). As such, this type of approach can increase teachers' confidence for being effective science teachers. According to the Carnegie Commission on Mathematics and Science Education (CCMSE, 2009), "no school factor is more important to learning than the quality of their teachers" (p. 34). If we are to improve STEM learning for all our students, we must "increase the supply of teachers who have strong working knowledge of mathematics and science *and* the pedagogical techniques necessary to teach math and science effectively" (p. 35).

While PBL offers a viable method for teaching inquiry in the STEM disciplines, it is neither readily adopted nor easily implemented (Ertmer & Simons, 2006). First of all, most teachers do not understand how scientific inquiry works in the field, so while they may have some theoretical understandings of inquiry, they don't know what it looks like in real life (Crawford *et al.*, 2005). This leads, then, to the second issue: teachers without inquiry experience lack key pedagogical knowledge about how to engage students with inquiry.

Goodnough and Cashion (2006) addressed these issues in their study examining the implementation of a PBL lesson in a high school science class. Specifically, Goodnough and Cashion see the adoption of PBL as a process of intense engagement in personal curriculum development, where teachers must "examine their beliefs…about the teacher's role in the classroom and the nature of…teaching and learning" within their disciplines and then "engage in decision-making based on their needs and the needs of their students" (p. 291).

This type of reflection and revision of personal pedagogy takes both time and effort, which is why peer and/or administrative support, including various opportunities for professional development, play a crucial role in PBL adoption (Goodnough & Cashion, 2006). If available, some support may come in the form of access to ready-made PBL units, such as the hypermedia program *Alien Rescue*, which was developed for middle school students and meets National Science Education Standards (Liu, Williams, & Pedersen, 2002). ***Table 1*** provides additional examples of STEM PBL units. Otherwise, as noted by Kostelny DeRoche (2006), in-service teachers are reliant upon professional development opportunities, such as workshops, peer training, and self-guided instruction, in order to learn about and implement new methods.

While professional development workshops and seminars may seem like good opportunities to hone teaching skills, Ball and Cohen (1999) lamented that,

Table 1. Sample STEM PBL units.

STEM Discipline	Driving Question	Primary Content Covered	For More Information
Science	• How can biological methods be used to meet our energy needs?	Biology—Cellular Processes	*http://biomass2biofuels.weebly.com/index.html*
	• How do drugs impact your body, your family, your community, and your world?	Chemistry, Math, Humanities	*http://www.hightechhigh.org/pbl/drug-movie/*
Technology	• How can we plan, design, and model a biomass conversion plant in our community?	Technology as a System	*http://edci627-unitplan.weebly.com/index.html*
	• What makes something strong?	Structural and Material Properties	*http://discover.education.purdue.edu/challengePBL/2000_2001/Strong/INDEX.HTM*
Engineering	• How is a new electrical product developed, engineered, and marketed for the public?	Physics, Engineering, Marketing	*http://www.hightechhigh.org/pbl/millionaire/overview.html*
	• How can we design, build, and test a water purification system?	Engineering Design; Science–Water Systems	Described in: J. L. Riskowski *et al.* (2009). Exploring the effectiveness of an interdisciplinary water resources engineering module in an eighth grade science course. *International Journal of Engineering Education, 25*(1), 181–195.
Math	• How can we, as concerned citizens, determine if the speed limits in Ripley County need to be changed to make them safer?	Algebra—Linear Equations	*http://iuedmoodle.educ.indiana.edu/moodle/mod/data/view.php?id=743*
	• How much of the Earth's surface can be seen from the International Space Station?	Geometry—Circle Formulas	*http://geometryonline.pbworks.com/w/page/14167950/PBL*

Other useful resources:

Buck Institute for Education: Project-based Learning for the 21st Century
http://www.bie.org

i-STEM Resource Network
https//www.istemnetwork.org/

PBL Academy: Advancing Project-based Learning in Every Classroom
http://iuedmoodle.educ.indiana.edu/pbl/index.html

Sample PBL projects, designed by middle and high school teachers in Crawfordsville, IN, are available at:
http://discover.education.purdue.edu/challenge/projectunits.html

Research and Practice articles in the *Interdisciplinary Journal of Problem-based Learning.*
http://www.docs.lib.purdue.edu/ijpbl/ (sign up for free access)

especially with one-off workshops (which they equate to yo-yo dieting), many of these professional development opportunities offer nothing more than a few tips or activities to try. Due to time constraints, they do not ask teachers to become serious learners by reflecting on both content and pedagogy. As Garet, Porter, Desimone, Birman, and Yoon (2001) concluded, after examining models of effective professional development: "sustained and intensive professional development" that includes a focus on academic subject matter and "gives teachers opportunities for 'hands-on' work" (p. 935) is more likely to be effective.

Pre-service teachers, on the other hand, may have an even more difficult time adopting and implementing PBL, as they have to rely on unpracticed personal pedagogy and their experiences as students in mostly traditional classrooms instead of actual classroom teaching experiences (Goodnough & Cashion, 2006; Peterson & Treagust, 1998). According to Berliner (1994), novice teachers tend to follow "context-free rules," such as "wait at least three seconds after asking a higher-order question" (p. 74). In contrast, experts tend to make decisions at an unconscious level, allowing them to respond more quickly and better to unexpected questions or situations (Hogan, Rabinowitz, & Craven, 2003). According to these characteristics, it may be hard for pre-service and novice teachers to provide the unscripted monitoring, questioning, and management required of a PBL facilitator. However, studies have shown that exposure to PBL through collaborative activities, instructor modeling, and reflection on effective practices can influence novice teachers to take the first steps toward adopting PBL and other student-centered approaches (Goodnough, 2003; Park & Ertmer, 2007; Peterson & Treagust, 1998).

It is important to note, however, that simply learning *how* to implement a student-centered method, such as PBL, does not mean that that a teacher will be able to do it effectively. As Trigwell and Prosser (1996) stated:

> …such changes are difficult to bring about, and are unlikely to occur through the attendance at, and participation in the occasional three-hour professional development workshop. A much more sustained and systematic approach is required, built upon teachers examining and critically reflecting on their own practices and the outcomes of those practices (p. 85).

Regardless of chosen method, pedagogical knowledge and competence are key factors to teacher success. Murphy, Neil, and Beggs (2007) found in their study of UK primary science teachers that teacher confidence, or self-efficacy, was another key factor in teacher success. The researchers noted that teachers were more likely to report confidence in practical aspects of teaching, but were less likely to report confidence in assessing students on practical work and integrating information and communication technology into science teaching. In a study exploring the self-efficacy of pre-service and new in-service teachers, Evans and Tribble (1986) found that pre-service teachers tended to possess less self-confidence in taking the role of intellectual model, especially when it came to activities such as assessing student work.

Another key point raised by Evans and Tribble (1986) is that pre-service teachers tend to demonstrate "incomplete perspective taking" (p. 83), which they describe as a failure to appreciate the importance of certain teaching skills. This is because, without experience, they do not yet see the need for them. For example, the researchers found that pre-service teachers placed heavy emphasis on subject matter knowledge, while new in-service teachers placed hardly any emphasis on subject matter knowledge and instead emphasized classroom discipline as their most serious concern.

The role of experience, both when learning a skill and practicing it, is of key importance to developing self-efficacy (Bandura, 19997; Schunk, 2000) During initial experiences within teacher training or professional development, it is important to scaffold successful performance to help build positive attitudes towards the strategies and skills being learned (Axtell, Maitlis, & Yearta, 1997). Tschannen-Moran and Hoy (2007) found that outside of the course, actual experiences with students made the strongest contribution to self-efficacy. Similarly, Tschannen-Moran and McMaster (2009) found that the most effective type of teacher professional development occurred when a teacher implemented a new strategy with his or her own students and was provided support by external coaching both before and after the experience.

It seems clear that approaches to teacher professional development must include not only content knowledge, but also opportunities to reflect, try out, and become confident with the skills or strategies being offered. According to Henson (2002), teachers with high efficacy/confidence tend to "experiment with methods of instruction, seek improved teaching methods, and experiment with instructional materials" (p. 128). Similar results have been reported for pre-service teachers (Tribble, cited in Henson, 2002). As such, increases in teaching efficacy may correspond to increases in efficacy for using new instructional methods, including PBL.

Given the severe shortage of highly qualified STEM teachers in classrooms today, as well as noted weaknesses in terms of both content and pedagogy for many career teachers in STEM fields (CCMSE, 2009), it is important to empower our future STEM teachers to make STEM learning exciting, accessible, and challenging for all students. As stated by the Carnegie/Institute for Advanced Study (2011), "tools are needed that deep-

en teachers' STEM knowledge and help them deliver personalized, rigorous STEM learning to all students" (p. 12). An integrated PBL/STEM approach may offer one of best tools available at this time. □

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Professional Development for Personalized Learning (PD4PL) Guidelines

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Most classrooms in the U.S. are composed of students with different learning styles and experiences as well as different achievement levels (Ferguson, 2001). Personalized learning is a unique way of students' learning determined by their own learning style, pace, and needs. Focusing on individual differences, personalized instruction aims to accommodate a variety of students to help them achieve mastery learning and performance (Ferguson, 2001). It is hard to promote students' personalized learning if there is no support for teachers' personalized instruction. The flexibility that technology brings to personalized instruction can help teachers contextualize their teaching practice for student diversity and student accountability for learning (Smith & Throne, 2009). However, the availability of technology itself does not promise effective technology integration for personalized instruction. There is a need for professional development that helps teachers learn to utilize technology for personalized instruction (Fok & Ip, 2006). In this article, the authors propose design guidelines for teacher professional development that aims to promote personalized instruction using a recommendation system.

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Introduction

Most classrooms in the U.S. are composed of students with different learning styles and experiences as well as different achievement levels (Ferguson, 2001). Personalized learning has been emphasized since the term "Personalized System of Instruction (PSI)" was first introduced by Fred Keller (1968). Individual students' characteristics and needs have to be considered for personalized learning. Focusing on individual differences, personalized instruction aims to accommodate a variety of students to help them achieve mastery learning and performance (Ferguson, 2001). However, it is hard to promote students' personalized learning if there is no support for teachers' personalized instruction. Personalized instruction requires time and constant effort for a teacher to plan lessons and learning activities for individual students (Keefe & Jenkins, 2008; Peel & McCary, 1997).

Technology can be perceived as one form of providing support for personalized instruction (Carolan & Guinn, 2007). The flexibility that technology brings to personalized instruction can help teachers contextualize their teaching practice for student diversity and student accountability for learning (Smith & Throne, 2009).

With the aid of technology, teachers can effectively complete multiple tasks, such as e-curriculum delivery, learning activity development, formative and summative electronic assessments, and use of interactive technology for personalized instruction based on student needs (Jones, Fox, & Levin, 2011).

A recommendation system can help teachers find activities or materials that match the students' learning preferences (Klasnja-Milicevic, Vesin, Ivanovic, & Budimac, 2011). Just as algorithms are used in commercial systems (e.g., amazon.com, netflix.com) to recommend certain items (e.g., shopping items, movies) for users, recommendation systems in learning contexts can be used to provide resources based on students' needs. Adaptive lessons and activities in a recommendation system can also help teachers determine teaching methods for individual learners (Chen, 2009; Fazlollahtabar & Mahdavi, 2009; Kardan, Speily, & Modaberi, 2011; Klasnja-Milicevic *et al.*, 2011; Wang, Wang, & Huang, 2008).

The availability of technology itself, however, does not promise teachers' effective technology integration for personalized instruction. There is a need for teacher professional development that helps teachers learn to utilize technology for personalized instruction (Fok & Ip, 2006). Such teacher professional development should be beneficial to student learning, since through personalized instruction teachers can cultivate learning by identifying individual students' needs and guiding each student to relevant resources (Keefe & Jenkins, 2008; Peel & McCary, 1997).

The purpose of this article is to propose design guidelines for teacher professional development that aims to promote personalized instruction. First, we define personalized learning and discuss its vital role in addressing students' individual needs. Then, we discuss the difficulties teachers face with practicing personalized instruction.

We also review different models that have been previously used in teacher professional development for personalized instruction. Finally, we present several design guidelines to help teachers practice personalized instruction along with a recommendation system.

Personalized Learning

Definition

Personalized learning refers to a unique way of students' learning determined by their own learning style, pace, and individual needs (Carolan & Guinn, 2007; Carroll, 1975; Johnson, Adams, & Cummins, 2012; Keefe & Jenkins, 2008; Miller, 2010). Students bring their own interests, learning styles, and preferences to class and gain different levels of success and satisfaction (Carroll, 1975; Keefe & Jenkins, 2008). Students prefer and learn better with the learning approaches that match their learning styles and needs (Dunn & Dunn, 1978).

Based on students' learning styles, prior experiences, and performance on assessments, teachers can do an initial screening and decide which learning activities would be relevant and useful for students (Dunn & Dunn, 1978; Fok & Ip, 2006; Klasnja-Milicevic *et al.*, 2011). Consequently, how to meet individual students' needs should be emphasized in considering how to promote personalized learning (Carolan & Guinn, 2007; Miller, 2010; Sands & Barker, 2004).

Importance

Personalized learning brings flexibility to students in the classroom. Students are able to achieve the goals at their own pace (Smith & Throne, 2009). Multiple choices are given for students to work individually, in pairs, or in small groups. Flexibility enables learners to adopt alternative learning paths if the existing learning path does not match their own learning styles and needs (Chen, 2007). Also, flexibility can reduce cognitive load during learning processes, and in turn performance can be enhanced (Chen, 2007).

Personalized Instruction

Definition

Personalized instruction refers to teachers' teaching

practices that aim to meet individual students' characteristics and needs (Keefe & Jenkins, 2008). Personalized instruction can maximize the capabilities of students, minimize the differences and limitations in the classroom, and effectively enhance students' learning (Sands & Barker, 2004). Personalized instruction does not mean that teachers teach everything in several different ways (Carolan & Guinn, 2007). Throughout interactions between the teacher and the student and a collective decision-making process, the meaningful learning paths can be further determined through personalized instruction (Anderson, 2007; Dolog, Simon, Nejdl, & Klobučar, 2008; Hamdan & Mattarima, 2012; Keefe & Jenkins, 2008; King-Shaver, 2008; Levy, 2008; Scigliano & Hipsky, 2010; Tobin & McInnes, 2008; Zajac, 2009).

Difficulties for Teachers in Enacting Personalized Instruction

Though personalized instruction can accommodate diversity in the classroom, it is not easy for teachers to implement, due to the following constraints: (1) lack of time, (2) lack of continuous support, and (3) lack of knowledge required for personalization.

(1) Lack of time. Personalized instruction requires teachers to take into account students' needs and then to revise pedagogy accordingly. However, heavy workload from both administrative and instructional responsibilities poses time constraints to the implementation of personalized instruction (Carolan & Guinn, 2007). Teachers have to deal with a variety of tasks, such as class management, communications with parents, grading, etc. (Lim, 2007). Consequently, teachers are likely to be hesitant to weave personalized instruction into their classrooms, due to lack of time (Carolan & Guinn, 2007).

(2) Lack of continuous support. Personalized instruction can be perceived as a burden without continuous support (Carolan & Guinn, 2007). Continuous support refers to a supportive school culture as well as the constant availability of relevant resources, including experts' help for personalized instruction (Miller, 2010).

(3) Lack of knowledge required for personalization. Traditional whole-class instruction in the classroom does not support every student's personalized learning (Sands & Barker, 2004). Some students may struggle in class unless their specific needs are met. For example, students with unique cultural and linguistic backgrounds could find their social studies class as challenging, especially when American perspectives dominate the class contents (Tobin & McInnes, 2008). Without sufficient knowledge about personalized instruction, it is unlikely that teachers will address students' diverse needs and guide students to relevant knowledge and skills in the classroom.

Teacher Professional Development

Teacher professional development helps teachers acquire the knowledge and skills required to improve student learning (Sands & Barker, 2004; Yost, Vogel, & Rosenberg, 2009). Professional development for technology integration helps teachers effectively utilize technology for specific goals in the classroom (O'Bannon & Judge, 2005). More and more, teachers believe that technology can help them practice personalized instruction (Carolan & Guinn, 2007).

Models Used in Teacher Professional Development for Personalized Instruction

Table 1 lists the models previously used in teacher professional development to promote personalized instruction. In ***Table 2***, each model proposes its own strategies to deal with the barriers discussed earlier for personalized instruction.

Based on the strategies in ***Table 2***, we have synthesized the following components for personalized instruction in teacher professional development: (1) contextualization, (2) collaboration, (3) ongoing school-based support, (4) inquiry-based training, and (5) personalized scaffolding.

(1) Contextualization. Teacher professional development should be aligned with an individual teacher's knowledge and needs (Carolan & Guinn, 2007; Klonsky, 2002; Miller, 2010; Otaiba *et al.*, 2011; Sands & Barker, 2004). One-size-fits-all teacher professional development would not be able to meet an individual teacher's needs. Contextualization, such as job-embedded training, customizes professional development to be relevant to the classrooms, where teachers will actually practice personalized instruction. Such contextualization can facilitate teachers' application of what they learned from professional development to their classrooms (Carolan & Guinn, 2007; Sands & Barker, 2004).

(2) Collaboration. Collaboration plays a critical role in teacher professional development for personalized instruction (Carolan & Guinn, 2007; Klonsky, 2002; Miller, 2010; Sands & Barker, 2004; Stover *et al.*, 2011). The issues relevant to continuous support can be resolved by collaboration among teachers. Through collaboration in a professional community, teachers can exchange their ideas or share solutions for personalized instruction (Boles & Troen, 2007; Casale, 2011; Klonsky, 2002; Miller, 2010; Stover *et al.*, 2011; Yost *et al.*, 2009). The pairing of novice and expert teachers helps both

Table 1. Teacher professional development models for personalized instruction.

Reference	Professional Development Model	Context	Lack of time	Lack of continuous support	Lack of knowledge required for personalization
(Carolan & Guinn, 2007)	Mentor Model	Middle School		✓	✓
(Klonsky, 2002)	Peer-Coaching Model	Unknown	✓	✓	
(Miller, 2010)	Community Coaching Cohort Model	Elementary School	✓	✓	✓
(Sands & Barker, 2004)	Three-Approach Model	Teacher Education			✓
(Stover, Kissel, Haag, & Shoniker, 2011)	Coaching Model	Literacy Field Across Grade Levels		✓	✓

Table 2. Strategies in teacher professional development for personalized instruction.

Lack of time	Lack of continuous support	Lack of knowledge required for personalization
Contextualization Job-embedded training (Klonsky, 2002; Miller, 2010) Aligned with context, content, and pedagogy (Klonsky, 2002)	*Collaboration* Development of professional community (Klonsky, 2002; Miller, 2010) Pairing novice and expert teacher, and creating the sense of collegiality among teachers (Carolan & Guinn, 2007; Klonsky, 2002) Ongoing interaction in the form of discourse (Stover *et al.*, 2011) Joint session of lesson-planning, modification, and implementation (Carolan & Guinn, 2007; Sands & Barker, 2004) *Ongoing school-based support* (Klonsky, 2002)	*Inquiry-based training* (Miller, 2010) *Personalized scaffolding* (Carolan & Guinn, 2007) Flexible instruction, differentiation, and one-on-one sessions (Carolan & Guinn, 2007; Stover *et al.*, 2011)

learn from each other (Carolan & Guinn, 2007; Klonsky, 2002).

(3) Ongoing school-based support. Without ongoing school-based support, teacher professional development for personalized instruction would become another short-lived experiment in teaching practice (Casale, 2011; Klonsky, 2002; Miller, 2010; Otaiba *et al.*, 2011; Stover *et al.*, 2011; Yost *et al.*, 2009). Ongoing school-based support should include personal assistance, such as onsite technical and/or continuing support from professional development trainers (Miller, 2010). Such support would bring about a long-term impact on individual teachers' personalized instruction.

(4) Inquiry-based training. Inquiry-based training is an approach which brings a questioning disposition to teachers in teacher professional development (Miller,

2010). Teachers not only reflect on their existing teaching practice through inquiry-based training, but also learn how to look for more solutions for personalized instruction.

(5) Personalized scaffolding. Teachers' personalized scaffolding deals with challenges that individual students encounter during the process of learning. Teachers need to understand what each student's needs are and what various types of scaffolding can be provided (e.g., extra study guides) (Carolan & Guinn, 2007). Personalized scaffolding should be included in teacher professional development to help teachers learn and model what should be done for personalized instruction.

Flexible instruction, differentiation, and one-on-one sessions can be part of personalized scaffolding. Flexible instruction is to support students' multiple ways of learning by giving them choices (Carolan & Guinn, 2007). Differentiation involves different ways of presenting and guiding content, process, and product per student need (Scigliano & Hipsky, 2010; Tobin & McInnes, 2008). By differentiation, personalized instruction helps individual students select the best ways of learning which meet their own needs. One-on-one sessions enable individual students to interact and communicate with teachers and gain the required support.

Professional Development for Personalized Learning (PD4PL) Guidelines

As discussed earlier, teachers face various barriers (i.e., lack of time, continuous support, and knowledge required for personalization) when implementing personalized instruction (Cole, 2008; Ferguson, 2001; Kameenui & Carnine, 1998). A recommendation system can help teachers find a way that matches students' learning preferences (Klasnja-Milicevic *et al.*, 2011). Adaptive lessons and activities in a recommendation system also can help teachers determine teaching methods for individual learners (Chen, 2009; Fazlollahtabar & Mahdavi, 2009; Kardan *et al.*, 2011; Klasnja-Milicevic *et al.*, 2011; Wang *et al.*, 2008).

Guidelines for designing teacher professional development of personalized instruction are proposed below to overcome the barriers discussed earlier. The context to apply those guidelines here specifically focuses on teachers' utilization of a recommendation system.

Barrier 1: Lack of Time

Guideline 1: Contextualize teacher professional development.

Teacher professional development can likely be disconnected from teachers' teaching contexts (Miller, 2010; Starkey *et al.*, 2009). In order to overcome this difficulty, teacher professional development utilizing a recommendation system should be aligned with teachers' specific needs to solve authentic problems that happen in their classrooms (Giordano, 2007; Hughs & Ooms, 2004; Kopcha, 2010; Rodrigues, Marks, & Steel, 2003; Stover *et al.*, 2011). This contextualized professional development can help teachers apply what they learned to their classrooms (Klonsky, 2002; Miller, 2010). Contextualized training for teachers using a recommendation system includes but is not limited to: (1–1) develop individual learners' profiles and diagnose students' learning characteristics, and (1–2) utilize a recommendation system.

(1–1) Develop individual learners' profiles and diagnose students' learning characteristics. A profile for each student should be developed and maintained to provide students with personalized feedback (Karmeshu, Raman, & Nedungadi, 2012). Helping teachers effectively develop students' profiles and diagnose their learning characteristics and progress are the foundation of personalized instruction (Keefe & Jenkins, 2008). The diagnosis of students' learning characteristics and progress includes checking students' prior knowledge, learning history, and cognitive style.

Many teachers traditionally identify students' learning status by directly observing students in the classroom (Keefe & Jenkins, 2008). In a recommendation system, student data which would be collected both during their learning activities online and from teachers' input of classroom experiences are automatically saved.

(1–2) Utilize a recommendation system. Authenticity in teacher professional development helps carry out what teachers consider significant and meaningful for personalized instruction (Keefe & Jenkins, 2008). Hands-on activities, such as small group training to develop assessments, help teachers learn how to effectively design and manage online resources in a recommendation system. Teachers should not only observe a demonstration of how to operate a recommendation system but also operate the system during training.

Barrier 2: Lack of Continuous Support

Guideline 2: Utilize various forms of continuous support.

Continuous support in various forms can be helpful for teachers to implement personalized instruction using a recommendation system. At the school level, ongoing support should include at least continuous maintenance of a recommendation system (e.g., technological trouble-shooting). At the professional com-

munity level, collaboration among teachers should be encouraged (Carolan & Guinn, 2007; Giordano, 2007; Hughs & Ooms, 2004; Klonsky, 2002; Kopcha, 2010; Miller, 2010; O'Bannon & Judge, 2005; Shymansky, Wang, Annetta, Yore, & Everett, 2010; Stover *et al.*, 2011).

Barrier 3: Lack of Knowledge Required for Personalization

Guideline 3: Build a personalized professional development environment to prepare teachers with knowledge and skills for personalized instruction.

A personalized environment for teacher professional development helps teachers experience personalized learning as learners and thus realize its importance. Teachers should be exposed to a type of pedagogy that is consistent with the design of teacher professional development (Kopcha, 2010). By modeling methods such as personalized scaffolding, teachers learn how to customize their own teaching for individual students in flexible and adaptive ways (Carolan & Guinn, 2007; Shymansky *et al.*, 2010). Teachers should understand technological pedagogical and content knowledge (TPACK) not only to utilize a recommendation system but also to make optimal decisions for each student (Thompson & Mishra, 2007).

Conclusion

The students' learning process has been characterized by three categories: (1) students' prior knowledge, learning style, and engagement; (2) teacher competence, teaching style, and commitment; and (3) organization of the learning environment (Keefe & Jenkins, 2008). Each individual student has preferred ways of learning, and teachers have their teaching styles to communicate with students (Messick, 1976). Match or mismatch between learning and teaching styles could impact learning.

A recommendation system utilizes various student data (e.g., student characteristics, learning progress, etc.) to suggest learning materials and activities adaptive to each student. The suggestions from a recommendation system prompt teachers to consider how individual students' learning can be guided. Contextualized professional development and continuous support utilizing a recommendation system are important in facilitating teachers' implementation of personalized instruction.

Future research should investigate the reliability and validity of a recommendation system's suggestions for adaptive learning materials. Also, teachers' tendency to make an optimal decision based on their recommendation systems' suggestions should be studied. Utilization of recommendation systems is expected to re-conceptualize not only teaching but also teacher education.

Teacher educators can implement personalization to help pre-service teachers model personalized instruction. For pre-service teachers, it is important to learn how to simultaneously play multiple roles (e.g., mentors, instructors, collaborators, etc.) to help bring about students' personalized learning (Keefe & Jenkins, 2008). □

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Developing Designer Identity Through Reflection

Monica W. Tracey
Alisa Hutchinson

As designers utilize design thinking while moving through a design space between problem and solution, they must rely on design intelligence, precedents, and intuition in order to arrive at meaningful and inventive outcomes. Thus, instructional designers must constantly re-conceptualize their own identities and what it means to be a designer. Within instructional design, professional identity development is intimately linked to the concept of design precedents. Reflective practice appears to be a natural avenue for supporting identity development in student designers, as it challenges them to think deeply about concepts and experiences through interpretation, evaluation, and revision. The authors conducted a preliminary study examining how graduate students in instructional design use reflection to build their identity as instructional designers within a design thinking framework. While this study was preliminary in nature, it represents an important first step in exploring how instructional design students can use reflective practice to develop the foundations of their professional identity, particularly within the design thinking framework.

Introduction

Scholars and instructors focused on design discuss specialized activities and particular habits of thought termed *design thinking* (Cross, 2007; Lawson & Dorst, 2009) and *reflective designing* (Lowgren & Stolterman, 2004). In this view, no single approach to designing can address every future situation effectively, so designers must be prepared to appreciate design situations subtly and with discipline, invent and re-invent processes, and take personal responsibility for the effects of their designs rather than handing off responsibility for quality outcomes to a single process or theory (Nelson & Stolterman, 2003). Designers act as human instruments, analogous to researchers in a naturalistic study, bringing their own acknowledged perspectives to the enterprise, working within emergent frameworks and adapting to situations unknown and unknowable in advance (Boling, 2008).

Students of instructional design and technology (IDT) bring different backgrounds and abilities to the classroom along with very different understandings of what design is and their role in it. Historically, IDT has focused on the systematic design process, client, and content, with very little on the designer role in design situations.

Aligning Instructional Design with the Broader Design Community of Practice

There is a growing trend in instructional design to shift from traditional, process-oriented conceptions of the field toward a view that aligns instructional design with the broader design community of practice and cross-discipline design thinking. Rather than being driven by models and strategy selection, this approach characterizes design as containing all of the activities and resources required to move from an ill-defined problem to a new and innovative solution that satisfies user needs. In this view, design is complex and iterative (Visscher-Voerman & Gustafson, 2004), requiring designers to embrace uncertainty as a motivating force; balance abstract principles against concrete details; alternate periods of intense work with relaxation in order to nurture inspiration; use models and prototypes to refine concepts and solutions; and leverage failure as a way to gain information and insight into the design problem (Cross, 2011).

Those who view design through this lens, and who study how it occurs in practice, present design not as a smooth, systematic process, but instead state that designers' values, belief structures, prior experiences, knowledge and skills, and their approach to design affect final outcomes (Nelson & Stolterman, 2003).

As such, design thinking highlights the central role that designers play in developing novel, functional solutions to ill-defined problems (Siegel & Stolterman, 2008). Designers recognize that problems and solutions are entwined concepts, but that the relationship between the two is complex, evolving, and often oblique. And as designers move through the design space between problem and solution, they must rely on their design intelligence and intuition, derived from large pools of experience and lessons learned from

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prior successes and mistakes, in order to arrive at meaningful and inventive outcomes. These experiences are also known as design precedents, or episodic memories of design experiences, both experienced and observed, that designers store, refine, and continually access as they make design decisions (Tracey & Boling, in press).

Thus, as the identity of instructional design evolves, instructional designers must also begin to re-conceptualize their own identities and what it means to be a designer. Developing a professional identity that is aligned with design thinking will exert an ongoing influence on designers' professional actions, values, beliefs, decisions, and commitments. They must position themselves as active drivers of the instructional design activity, whose judgment, experience, and intuition guide the efforts and resources needed to move between problem and solution. This raises questions related to how professional identity is developed and what experiences support that process for established and emerging designers.

Developing Designer Professional Identity

While little attention has been paid to this topic in instructional design, the development of professional identity has been studied extensively in other fields (Luehmann, 2007). Drawing on this literature, several core principles emerge: professional identity is socially constructed via interactions with others, particularly those in one's community of practice; professional identity is constantly being formed and reformed, although changes to core identity features may develop slowly; and professional identity is constituted in and emerges from dynamic interpretations and narrations of experiences (see Luehmann, 2007, for a review). Through these parallel activities, identity emerges, and the individual is recognized (by self and others) as being a particular type of person (or designer).

Within instructional design, professional identity development is intimately linked to the concept of design precedents introduced earlier. As mentioned, design precedents constitute an individual designer's internal reference bank of design experiences that influence and feed ongoing design decisions. For instructional designers working within the design thinking framework, identity development will entail the formation of design precedents that address relevant aspects of design thinking, such as uncertainty, intuition, failure, the balance between the abstract and the concrete, and the role of prototypes in design.

Experienced designers already have a rich portfolio of memories and beliefs; thus, identity work will involve reconsidering and recasting prior experiences in light of these concepts, and assimilating new experiences within the design thinking paradigm. Even with this foundation in place, however, reshaping professional identity involves assuming risks and accepting vulnerability, as the new identity is assimilated and aligned with core features of an individual designer's existing identity.

For novice instructional designers, who lack the broad pool of experience, knowledge of their beliefs about design, and self-awareness of their emerging identity as designers, the process of identity formation will require substantial guidance, support, and feedback in order to overcome the risks inherent in the process as they construct a preliminary store of design precedents and establish a vocabulary for narrating and interpreting their experiences. A key component of graduate training in instructional design may rest in helping novice designers build the preliminary foundation of their professional identity.

Reflection and Design

Reflective practice appears to be a natural avenue for supporting identity development in novice designers, as it challenges students to think deeply about concepts and experiences through interpretation, evaluation, and revision. The emphasis on reflection as a means of learning extends back to Dewey (1991), while its use in the construction of professional identity was highlighted in the work of Schön (1983) and his conceptions of reflection-in-action and reflection-on-action. Reflection-in-action focuses on narratives and interpretations that arise while work is occurring, while reflection-on-action is centered on narratives and interpretations that emerge as prior experiences and practices are (re)considered and (re)constructed (Schön, 1983).

Novice designers can leverage reflection to interpret and manage issues of uncertainty, instability, uniqueness, and conflicted values that are inherent in ill-structured design problems, both during and after the design experience. Thus, reflection can be an important tool in supporting novice designers as they begin the important work of constructing design precedents and establishing professional identity.

Reflection to Build Designer Identity

In order to explore these concepts and ideas, we conducted a preliminary study examining how graduate students in instructional design use reflection to build their identity as instructional designers within a design thinking framework. The subjects included 40 instructional technology graduate students across two semesters of a foundational course in instructional systems design at a large, urban research university in the Midwest region of the United States. As part of the course requirements, students were required to maintain a reflection journal, which was shared with the instructor via Google documents for feedback and

assessment over the semester. In addition, the course included a case study component, which gave students hands-on experiences in developing instructional design plans.

Because novice designers may benefit from scaffolding in order to better understand the concepts associated with design thinking, we opted to use structured reflection, or reflection in response to assigned topics or questions, to spur narratives and interpretations that align with specific features of design thinking. Lin, Hmelo, Kinzer, and Secules (1999) describe such prompts as providing "learners with a means of externalizing mental activities that are usually covert" (p. 49), particularly when they focus on helping students understand decisions and actions by exploring and understanding their underlying reasoning and learning processes. For this study, reflection prompts were centered on concepts, beliefs, and experiences with relating to design and the self-as-designer, and typically asked students to delve into the "how" and "why" behind their responses. More specifically, reflection prompts urged students to explore:

- **Beliefs about design:** What is design, what is instruction, and what do designers do?
- **Experiences with design:** Personal experiences with design, uncertainty, and inspiration.
- **Awareness of emerging designer identity:** Why they want to be designers, their personal characteristics relevant to design, how will they develop their design intelligence, and what does it mean to them to be a designer?

Students were asked to reflect in their online journals in response to these prompts at established points during the semester, primarily during the first several weeks of the class and then again in the final weeks, as they completed work on an instructional design case study. The course instructor had access to the journals and provided formative feedback within the document itself. Formative feedback is typically developmental in nature and should serve to provide a "course correction" (Berge, 2002, p. 187) to ensure that student responses are moving in the direction of deeper reflection, which was the approach taken for this class.

The online context used for this course was particularly conducive to providing students with formative feedback, as the ease of access supported prompt instructor responses that could be easily incorporated in subsequent student responses. Furthermore, the journal became a "living document" that allowed students to witness and review their own progress and development as additional reflective entries were added over the semester.

Unproductive and Productive Reflection

When assessing student responses for the purposes of this study, it was crucial to develop clear guidelines for determining whether or not genuine reflective learning was occurring, which were distinct from the grading procedures used in the institutional context. Several approaches to evaluating reflection exist in the literature, typically focusing on conceptualizing degrees of reflection along a scale encompassing mere description on one end and continuing through deeper levels of reflection, such as evaluation, dialogue, critical analysis, etc. (see Blaschke & Brindley, 2011, and Davis, 2006, for reviews). In establishing the criteria for this study, we drew on the work of Davis (2006), who proposed unproductive vs. productive reflection as binary categories for assessing student responses.

Unproductive reflection is characterized as mainly descriptive, lacking in analysis, and reliant on unconnected lists of ideas or issues. Productive reflection, on the other hand, includes integration and analysis, the questioning of assumptions, and multiple ways of seeing, all of which support the type of narrative considered necessary for developing professional identity. It should be noted that unproductive reflection is not necessarily a negative label; instead, it might better be considered pre-reflection, or the foundation for moving into productive reflection with support, feedback, and experience.

When assembling student reflection for this study, we began by removing any identifiable information and aggregated student responses per question in a master spreadsheet. This allowed us both to view the response set as a whole and to set up a variety of comparison scenarios. During initial data analysis, we followed an iterative process of reading, rereading, and taking notes about what the data was saying to document emerging questions and patterns. An inductive content analysis approach was used for segmenting the data to identify productive and unproductive reflection and to identify themes and concepts on beliefs about design, experiences with design, and awareness of emerging designer/identity/self-as-designer.

As these themes and concepts emerged, we relied on the following research questions to guide our analysis and interpretations:

- Are there trends in productive reflection across the semester and, if so, what are their implications?
- Are there trends in productive reflection within prompt domains (i.e., beliefs, experiences, and identity awareness), and, if so, what are their implications?

- Were students able to use reflection to begin to construct aspects of their own designer identity, particularly relating to uncertainty tolerance and solution ambiguity?

First, we considered productive vs. unproductive responses across the course of the semester in order to understand whether students were able to demonstrate improvements in reflective skills within the structured reflection approach. We discovered a persistent trend across the weeks toward a greater number of reflective responses, moving from less than half of responses qualifying as productive during the first week, to 70% labeled as productive for the final entry. This finding demonstrates that reflective skills can show improvement with time, practice, and guidance. It also lends support to the idea that unproductive reflection can provide the foundation for future productive reflection, with the appropriate formative feedback and support.

One student in particular illustrated how reflection can be developed in an individual student in this context. This student was unable to generate productive reflection during the first week, which included prompts related to defining design, personal design experiences, and uncertainty. However, the student was able to effectively incorporate formative feedback and became consistently productive in responses during later weeks. This student also had a clear understanding of personal identity as someone who was able to learn from failure and maintain a positive attitude, and appeared to be able to leverage these qualities, in tandem with feedback and experience, to improve performance throughout the semester. Perhaps more importantly, the student was also able to connect these existing identity characteristics to the emerging identity as a designer, and frequently referred to them as valuable to future work in instructional design throughout the remainder of the course.

We also considered productive reflection in relation to the reflection prompt domains (i.e, beliefs, experiences, and identity awareness) to explore whether novice designers were more productive in relation to particular types of design precedent topics. However, no clear trends emerged in this analysis, although there was a modest tendency for greater reflection over time within each domain. We were curious whether some design precedents were easier for subjects to consider within the reflective framework, but our findings suggest that students need support in developing reflective skill in relation to multiple identity constructs.

Reflection on Designer Uncertainty and Ambiguity

Tolerance for uncertainty is a key skill for designers within the design thinking framework, so we were interested in whether students could use reflective practice as an avenue for incorporating this quality into their identity as designers. Subjects were asked to describe experiences and feelings relating to uncertainty and their personal tolerance for this state, first in Week 1 and again in Week 5 of the class. We found that students were able to generate higher levels of productive reflection in response to the second uncertainty prompt (55% productive for Week 1 vs. 70% productive for Week 5). Perhaps more importantly, we found that many students who displayed a negative orientation toward uncertainty during Week 1 were able to reframe their perceptions of uncertainty in alignment with the value that design thinking places on this state. Of the 24 students who indicated an initial negative orientation toward uncertainty during Week 1, all either displayed a positive orientation toward uncertainty during Week 5, or qualified negative orientation by addressing its value and their intention to overcome their discomfort with uncertainty, with some including specific plans and actions that they would take to make this shift.

We were also curious as to whether uncertainty tolerance had a relationship to the desire to preserve ambiguity in the design space. In Week 4 of the course, students were asked to list several phrases that would describe how they planned to work as a designer, and 19 included a reference either to preserving solution ambiguity (N = 6) or pinning down a solution early in the design process (N = 13) in their responses. We then looked at how this set of subjects reflected on uncertainty during Weeks 1 and 5. We found that, among those that would preserve solution ambiguity, two students displayed positive uncertainty orientations in Weeks 1 and 5, while the remaining four moved from a negative orientation in Week 1 to a positive orientation in Week 5. Among the 13 students who identified with pinning down a solution early, two had previously indicated positive attitudes regarding uncertainty in Week 1 and 5 responses. The remaining 11 followed a negative/positive uncertainty orientation pattern in their responses to Week 1 and Week 5.

While these findings may appear contradictory, in that students who aligned themselves with early solution identification also moved toward greater uncertainty tolerance, it is important to remember that identity development is a complex, ongoing, and recursive process that may include contradictions and inconsistencies as beliefs and experiences are interpreted and incorporated by the individual.

Conclusions

While this study was preliminary in nature, it represents an important first step in exploring how

instructional design students can use reflective practice (including both reflection-on-action and reflection-in-action) to develop the foundations of their professional identity, particularly within the design thinking framework. The data indicated that scaffolding via prompts and feedback can support students in moving from unproductive to productive reflection and can lead to development of an emerging designer identity. Within these results, we saw that this practice was particularly useful for helping students conceptualize, modify, and solidify identity attributes relating to uncertainty tolerance, a crucial quality within the design thinking approach.

This study has produced numerous additional opportunities for future research on this topic. First, we are interested in looking more closely at the reflection prompts; it is certainly possible that revising the structure, content, and/or number of prompts may prove useful for supporting the development of reflective skills in students. We also believe that deeper research is necessary in relation to the prompt domains (beliefs, experiences, and identity awareness); while our preliminary research did not reveal any trends, further investigation of these constructs and their role in identity development is warranted. The online learning context may facilitate the incorporation of peer feedback into the reflective learning process. Given the importance of discourse and dialogue to the social construction of identity (Gee, 2000), providing students with peer reflection groups may provide additional opportunities for feedback and exposure to multiple perspectives.

Finally, because identity development is both social but also intensely personal, exploring the relationship between reflective practice and identity formation may also be well-suited to individual case studies, where factors that enable or impede identity development can be examined more closely and within the same subject over time.

As the instructional design community continues to redefine the field's identity through alignment with the larger design community and design thinking approaches, it will be necessary to reconsider what it means to be a designer within this framework. Graduate programs in instructional design will also need to consider how they can support students in establishing a preliminary sense of professional identity through instructional practices and curricular requirements.

Reflective practice is an important tool for identity development commonly used in other professional training programs, and as this study demonstrates, it holds great potential for supporting instructional designers in developing design precedents and other significant foundational factors of designer identity. □

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How Task-Centered Learning Differs from Problem-Based Learning: Epistemological Influences, Goals, and Prescriptions

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Many recent models of learning and instruction center learning on real-world tasks and problems to support knowledge application and transfer. Among these models are problem-based learning and task-centered learning, two different approaches to learning that are often mistaken for one another. However, there are important distinctions between these two approaches to learning with regard to epistemological influences, goals, and prescriptions. In this article the authors provide a description of task-centered learning and differentiate it from the concept of problem-based learning.

Introduction

A pragmatic view of higher education sees learning as a way to prepare students for real-world situations. In this view, education should require students to apply knowledge, complete meaningful tasks, and solve problems (Jonassen & Strobel, 2006; The Secretary of Education's Commission on the Future of Higher Education, 2006; The Secretary's Commission on Achieving Necessary Skills, 1991). These skills become more and more important as access to information increases (Lyman & Varian, 2003). The Internet, for instance, is a vast source of decontextualized information, providing the user with facts and procedures on almost any subject. But this vast source does not necessarily provide specific directions on how a person could apply its information to complete a current problem or task within a specific context. Thus, a person may need problem-solving skills that enable him or her to apply this information to a specific problem or task. Despite the importance of knowledge application and problem-solving skills, the development of these skills has been somewhat neglected in education (Jonassen, 2000; The Secretary's Commission on Achieving Necessary Skills, 1991; van Merriënboer & Kirschner, 2007).

To promote learner ability to apply knowledge and solve problems, many recent models of learning and instruction advocate using real-world problems or tasks as a foundation for learning. Two such models are task-centered learning (TCL; Merrill, 2002, 2007; van Merriënboer & Kirschner, 2007) and problem-based learning (PBL; Barrows, 1996; Hung, Jonassen, & Liu, 2008). Because some overlap exists between these two learning models, implementations of TCL can be confused as implementations of PBL. Therefore, in this article we differentiate TCL from "pure" PBL because there are specific and important differences between the approaches.

Task-Centered Learning

TCL is a model of teaching and learning that uses real-world tasks as a central strategy. TCL has been called several different terms, such as problem-centered instruction, task-centered instruction, or learning/instruction based on learning tasks (Merrill, 2007; Merrill, Barclay, & Van Schaak, 2008; van Merriënboer, 1997; van Merriënboer & Kirschner, 2007). We choose to use the term "task-centered learning" to describe this approach because the focus of this type of learning and the instructional approach used is not simply "instruction" in the behavioral sense of the word (i.e., direct instruction). TCL advocates certain practices for instructional design and teaching with the goal of enhancing student learning and transfer.

Instead of focusing on learning through lecture, TCL centers learning on learning tasks, or activities that require learners to apply knowledge in a specific domain by completing a carefully chosen series of real-world tasks (see ***Figure 1***; Merrill, 2007; van Merriënboer & Kirschner, 2007). A TCL process might look similar to the following: An instructor presents students with a new task to be completed. This task is complex and is based on real-world performance within the subject area of the

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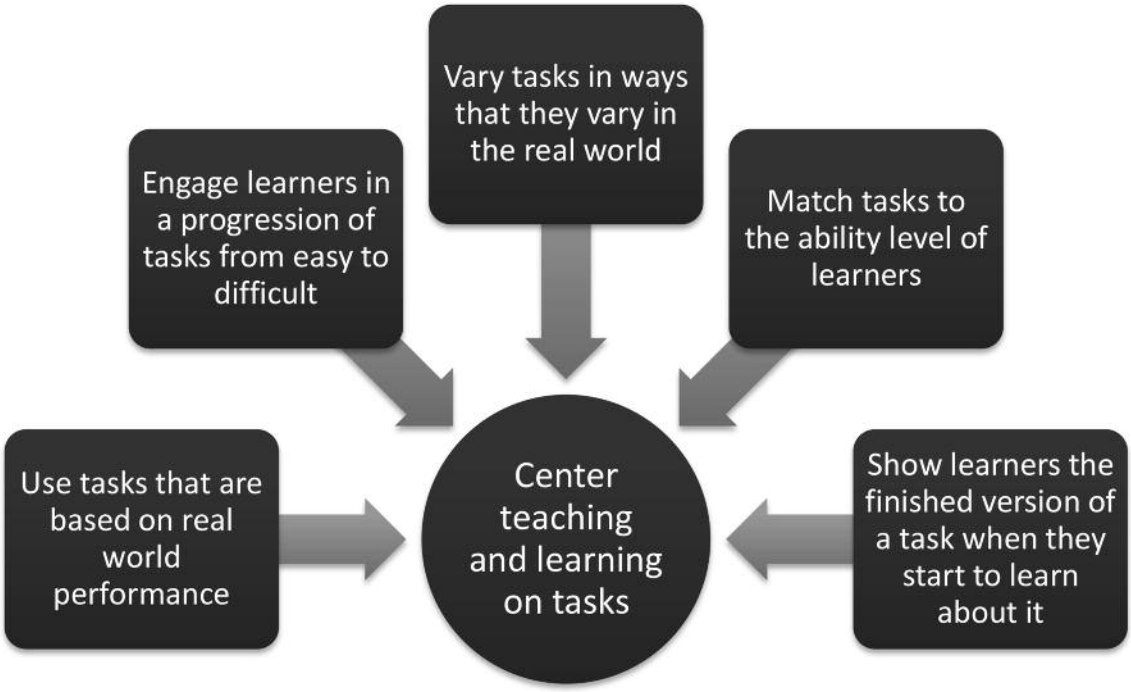

Figure 1. General task-centered learning prescriptions (Merrill, 2007; van Merriënboer & Kirschner, 2007).

class. For example, in a biology class the task might require students to follow the scientific method to investigate the cause of a widespread fish disease. After being presented with the task, students then learn subject matter that is relevant to the task. In the biology example, this might include the steps in the scientific method, information about diseases, and the effects of these diseases on fish. Students are also taught strategies for completing the real-world task. When students have received enough support in the form of knowledge and strategies, they are directed to complete the task. When students complete this task, they are presented with another task that is more difficult or complex than the first. This additional task may require the use of additional knowledge of the subject matter, or it may have to be performed with less support. Students complete a progression of additional tasks and continue to learn and apply knowledge to the completion of these tasks. In each additional task the level of support given to students is faded as students gain expertise in the subject area. Knowledge transfer is supported through the selection of tasks that have real-world relevance and that offer a high level of variability (van Merriënboer & Kester, 2008; van Merriënboer & Kirschner, 2007).

Problem-Based Learning

Problem-based learning is a learner-centered approach in which problems form the focus of the learning experience, and students gain knowledge with which to solve problems in a self-directed manner (Barrows, 1996) It is important to note that implementations of PBL have varied widely in the amount of learner support and guidance given to learners and the complexity of problems that learners solve (Barrows, 1986; Bereiter & Scardamalia, 2000; Savery & Duffy, 1995). For instance, some reports of implementations claiming to be PBL have included a high amount of instructional support and guidance for problem solving, while other reports have included a very low amount of instructional support and guidance (Bereiter & Scardamalia, 2000; Spector, 2003). The PBL concept has become so general that almost any form of learning that uses problems in any way has been called PBL. Therefore, we chose a specific form of PBL, what we call "pure" PBL, to make a meaningful comparison to TCL. "Pure" PBL refers to those forms of learning and teaching that acknowledge medical school origins and follow a structure as put forth by Barrows (1986, 1996; see also Bereiter & Scardamalia, 2000; Savery & Duffy, 1995). We chose "pure" PBL because this form of PBL has established principles and practices that can be meaningfully compared to TCL.

"Pure" PBL includes student-centered learning in small groups in which problems provide the impetus for learning and make up the organizational structure of the learning experience (Barrows, 1986, 1996). In this approach, students are provided with a problem to solve or task to complete. They work in groups in a student-directed process to solve the problem or complete the task. In "pure" PBL, the instructor acts as a facilitator who does not provide information to learners or provide learners with direct answers to questions in order to help

learners gain skills for finding their own answers (Barrows, 1996; Hung *et al.*, 2008). Learners must self-direct their own learning and information-gathering processes in "pure" PBL (Barrows, 1996; Savery & Duffy, 1995). When one problem or task is completed by learners, they are required to complete another problem or task. Learners continue to solve problems in a self-directed and group-oriented way throughout the course of the learning experience.

"Pure" PBL as described in this way has been criticized for its inefficiency, due to a deficiency of direct instructional guidance about concepts and procedures important to a specific discipline (Azer, 2000; Glew, 2003; Kirschner, Sweller, & Clark, 2006; Spector, 2003). However, researchers have found that in some cases, learners gain enhanced problem-solving abilities and more flexible knowledge as a result of PBL experiences (Hung *et al.*, 2008).

Task-Centered Learning vs. Problem-Based Learning

On the surface, TCL seems similar to PBL. Both center learning on problems or tasks that are based in real-world practice, and both require learners to apply knowledge to complete these tasks or solve problems. Both also involve learners in tasks or problems throughout an entire learning experience. However, important differences between these two approaches exist, including *epistemological influences, goals,* and *prescriptions*. These differences are described below, and ***Table 1*** also summarizes these major differences.

Epistemological Influences

Although neither PBL nor TCL emerged from a specific epistemological stance, arguments have been made as to their epistemological roots. PBL is commonly cited as following constructivist assumptions about learning that view knowledge as socially and individually constructed, thinking as a distributed phenomenon, and understanding as situated within a specific context (Hung *et al.*, 2008; Savery & Duffy, 1995). Situated learning (which views learning as a situated phenomenon within a specific context) and social constructivism (which posits that knowledge evolves during social negotiation) have also influenced PBL (Dolmans, De Grave, Wolfhagen, & van der Vleuten, 2005; Savery & Duffy, 1995).

In contrast, epistemological influences on TCL include such various areas as cognitive information processing, situated learning, and andragogy. Aspects of cognitive information processing mentioned in TCL models include the development of schema in long-term memory and a focus on and adjustment for limitations in human working memory (Merrill, 2002, 2007; van Merriënboer, 1997; van Merriënboer & Kirschner, 2007; van Merriënboer & Sluijsmans, 2009). Elements of situated learning and andragogy which have especially influenced TCL include a focus on meaningful situated behaviors in realistic settings (van Merriënboer & Kester, 2008). Teaching and learning practices such as those suggested by motor learning (in which performance of physical tasks is emphasized and whole task sequencing is conducted), and cognitive apprenticeship (in which a "master" helps an "apprentice" complete tasks by making implicit processes visible to the apprentice) have also influenced TCL (Gagné & Merrill, 1990; Merrill, 2002; van Merriënboer, 1997; van Merriënboer & Kester, 2008).

In sum, both PBL and TCL are influenced by situated learning, and these models both attempt to situate learn-

Table 1. Summary of the differences between task-centered learning and problem-based learning.

	Task-Centered Learning	Problem-Based Learning
Epistemological Influences	Cognitive information processing, situated learning, andragogy, motor learning, cognitive apprenticeship	Constructivism, situated learning, social constructivism
Goals	Application and transfer of knowledge to realistic contexts; efficient and effective learning and transfer of knowledge	Flexible knowledge, problem-solving skills, self-directed learning skills, effective collaboration, and motivation
Prescriptions	Facilitator provides specific types of learner support and guidance on task performance (including procedural and supportive information) that is faded over time; group learning depends on the nature and complexity of task	Facilitator typically avoids providing specific resources to use, learning guidance, scaffolding, or direct answers to questions in order to enable learners' development of problem-solving skills; group learning is essential

ing activities through the use of problems and tasks that may feature contextual elements, such as social and physical environments similar to real-world environments. However, TCL is more heavily influenced by cognitive information processing and also has a variety of other influences (including andragogy, motor learning, and cognitive apprenticeship). PBL has had strong constructivist epistemological influences, which are not generally present in a TCL approach. These differences in underlying epistemologies have an influence on how PBL and TCL differ in *goals* and *prescriptions*.

Goals

The goal of PBL is to develop problem-solving skills among learners while they learn (Barrows, 1996; Jonassen, 2000). More particularly the goals of PBL environments for learning have included flexible knowledge, problem-solving skills, self-directed learning skills, effective collaboration, and motivation—aims which follow constructivist assumptions about teaching and learning (Hmelo-Silver, 2004). Conversely, TCL is more pragmatically oriented; the major goal is to produce effective application and transfer of knowledge to realistic contexts (Merrill, 2007; Merrill *et al.*, 2008; van Merriënboer, 1997; van Merriënboer & Kirschner, 2007); however, because complex tasks are often used in learning, problem-solving skills may also be gained by learners in a TCL experience (van Merriënboer & Kester, 2008). Efficiency—or achieving learning application and transfer in as short a time as possible—is another goal of TCL, which distinguishes it from PBL. Cognitive information processing models of sensory, working, and long-term memory are often used to explain how TCL environments might support learning effectively (e.g., van Merriënboer & Sluijsmans, 2009; van Merriënboer & Sweller, 2005). Thus, TCL models may focus on the importance of working memory capacity and cognitive structures for learning by suggesting that learning activities should connect to a learner's existing cognitive structures and avoid overloading a learner's limited working memory capacity. These overall goals lead to different prescriptions for instructional design within TCL and PBL.

Prescriptions

While both TCL and PBL center learning on problems or tasks, they differ in task sequencing and instructional support. In a PBL episode, the instructor/facilitator typically avoids providing learning guidance, scaffolding, or direct answers to questions to enable learners' development of problem-solving skills (Barrows, 1996; Hung *et al.*, 2008). For example, when asked a direct question about a specific subject-matter item, a PBL facilitator will suggest that students find the answer individually or as a group. Guidance in the form of specified reading assignments or information sources is also discouraged to allow learners to go through realistic, self-directed problem-solving processes (Savery & Duffy, 1995). Groups of learners working together to solve problems is also an essential characteristic of PBL (Barrows, 1986, 1996). These prescriptions are aligned with constructivist assumptions about the central role of the learner in the learning process and the situated and social nature of understanding.

In contrast, TCL advocates specific types of learner support and guidance on task performance (including procedural and supportive information) that is faded over time (van Merriënboer & Kirschner, 2007). Thus, while an instructor in a PBL approach would not provide suggestions on how learners are to proceed in solving a problem, an instructor in a TCL approach might tell learners what steps to take and what resources to use (such as specific prior knowledge items, Websites, job aids, presentation notes, textbook sections, etc.) when completing a task. In TCL an instructor might also show learners how to do the task and explain the reasons for doing tasks in a certain way. In contrast to PBL, an instructor in a TCL approach may also provide direct answers to learners' questions as appropriate and help guide learners in their knowledge acquisition. These prescriptions are aligned with a cognitive information processing view of learning in which learners have limited working memory capacity, but gain more elaborate mental knowledge structures as their expertise increases (Kirschner *et al.*, 2006; van Merriënboer & Sluijsmans, 2009). The prescriptions of TCL are also aligned with a cognitive apprenticeship approach to teaching and learning, especially with the use of modeling, scaffolding, coaching, and articulation (Brown, Collins, & Duguid,

Is it PBL or TCL? If the learning environment involves learners in a series of carefully sequenced problems/tasks and the instructor has identified the subject matter that learners need to know to complete the tasks, then it is likely TCL. If the learning environment requires learners to identify the subject matter they need to know themselves, this would be more in line with a "pure" PBL approach. If the learning environment provides novice students with information about the subject matter that relates to the problem or task, then it is likely TCL. If the learning environment requires even novice students to find their own information, this approach would be more in line with "pure" PBL. If the learning environment provides novice students with guidance on the steps to take to complete the problem or task, then this would be a TCL approach. If the learning environment requires novice students to determine these steps on their own, this would be a "pure" PBL approach.

1989; Collins, Brown, & Holum, 1991).

An instructor in a TCL approach provides a high level of support and guidance for learning when learners work on initial tasks and then fades this support and guidance over time as learners gain expertise in working on more complex tasks. After learners gain sufficient expertise, the level of support and guidance that they receive would probably be similar to the level of support and guidance that novice learners receive in a "pure" PBL approach.

Models based in TCL are designed to balance the use of learner-initiated tasks with instructor support, thereby engendering effective and efficient learning (Merrill, 2002; Merrill & Gilbert, 2008). With regard to the use of learner groups in learning, not every model of TCL specifies whether groups should be formed for learning. Instead, a decision of whether to form groups is based on the realistic nature and complexity of the task (i.e., if the task is complex, or generally completed in groups in the real world, then group learning would be warranted).

Discussion and Conclusion

The epistemologies behind TCL and PBL lead to differences in goals and prescriptions in each approach. The overall goal for a TCL approach is to support effective application and transfer of knowledge; however, the overall goal for a PBL approach might focus on building students' problem-solving, self-directed learning, and collaboration skills. In PBL, the learner is required to find, evaluate, and apply knowledge to a problem or task with little instructional support. In TCL carefully sequenced series of tasks/problems are chosen and instructional support is given to novice learners to help them find, evaluate, and apply knowledge to a problem or task. This support is faded over time as learners gain expertise. In PBL, group work is seen as an essential aspect of the learning and problem-solving experience. In TCL group learning depends on the nature and complexity of the task. TCL may provide a practical middle ground between the cognitive information processing view that knowledge can be provided to learners in ways that increase the efficiency of learning, and the constructivist view that learners must solve complex problems in order to construct their own knowledge.

Both TCL and PBL center the learning experience on real-world problems and tasks that they require learners to complete. Both approaches also require learners to apply their knowledge of the subject area to complete these real-world problems and tasks. In the information age, learners will need to know how to apply knowledge in order to complete real-world tasks and solve problems. More models for approaches to learning that support learner application of knowledge like TCL and PBL will be needed to help our learners succeed in a changing world. □

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Massive Open Online Courses (MOOCs): Current Applications and Future Potential

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Contributing Editor

Massive Open Online Courses (or MOOCs) are the subject of numerous recent articles in *The Chronicle of Higher Education, The New York Times,* and other publications related to their increasing use by a variety of universities to reach large numbers of online students. This article describes the current state of these online course offerings, their advantages and disadvantages for universities and students, and their future potential for changing the face of higher education.

Introduction

Traditional colleges and universities are facing a number of issues, including increasing tuition, reduced state support for public institutions, declining endowments (Vardi, 2012), decreasing enrollments, and increasing competition from for-profit institutions (e.g., Walden University, etc.). While these concerns are being addressed in various ways by different institutions, a relatively new technology—**M**assive **O**pen **O**nline **C**ourses, or MOOCs—is increasingly being discussed as an option that could deliver higher education materials to hundreds of millions of people at potentially lower costs (Galagan, 2012; Vardi, 2012).

MOOCs are, in essence, large-scale educational courses where people interested in a particular topic are brought together to learn collaboratively through blogs, tweets, and other Internet resources. There are generally

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no registration or tuition fees, although there are typically facilitators as well as defined start and end dates (DeSilets, 2011), and fees for those taking proctored exams. These new online courses can attract thousands of participants from around the world, with students openly sharing their expertise and knowledge with each other, while also managing their own learning processes (Tschofen & Mackness, 2012).

These new educational tools have generated a high level of excitement as well as the investment of millions of dollars from investors and universities into companies such as Audacity, Coursera, and edX (Korn & Levitz, 2013b). In addition, they have earned praise for bringing high-quality education to students who may not have access to higher education (e.g., those in remote places) as well as for bolstering teaching quality and productivity (Carr, 2012).

History of MOOCs

Massive Open Online Courses have their roots in the free online versions of existing courses taught by a number of well-known universities. While these offerings were taken by millions of students, the courses were primarily composed of reading lists and lecture notes (Gose, 2012).

One of the first of these courses, "Connectivism and Connective Knowledge," was offered in 2008 by Stephen Downes and George Siemens at the University of Manitoba (Fini, 2009). This course attracted numerous adults and various informal learners and utilized a large number of technological tools proposed by the facilitators or suggested by participants, including chat, mailing lists, discussion forums, Wikis, a Web conferencing system, personal blogs, and numerous other tools.

"Introduction to Artificial Intelligence" was another course in this area, offered by Stanford in 2011 (Carey, 2012; Carr, 2012; Hill, 2012). Taught by Sebastian Thrun and Peter Norvig, this online, non-credit course was offered free to anyone, with an original expected enrollment of 10,000, although it ended up enrolling a total of 160,000 students. Utilizing a course Web home and a customized learning management system, the course included lectures, homework, and assessments. While many students did not finish the course, some performed as well on the assignments and exams as the students taking the traditional campus-based course.

The Massachusetts Institute of Technology was another of the institutions offering these early MOOC-like courses at approximately the same time (DiSalvio, 2012). Their first online course in this area, "Circuits and Electronics," was offered in 2012, with 155,000 people registered for the course. Of this original number, approximately 23,000 tried the first problem set, 9,000 passed the midterm, and 7,157 passed the full course.

Characteristics of MOOCs

While MOOCs can vary widely based on content, students, faculty, and the organization which offers the course, there are also a number of core characteristics that define this type of offering and its presentation methodology. These characteristics help to define these courses and their instructional potential.

The most obvious feature of MOOC-based courses is their *open availability* to everyone with Internet access. Along these lines, individuals are free to join, create, interact, analyze, and reflect based on their learning needs, with students joining, participating, and withdrawing with great frequency. Enrollments tend to be quite high (generally over 500 participants), although the withdrawal and dropout rates (often greater than 50%) are also significant (Koutropoulos, Gallagher, Abajian, de Waard, Hogue, Keskin, & Rodriguez, 2012).

As noted above, only a fraction of enrolled students typically complete these courses (often under 10%), with students often picking and choosing specific lessons based on content that interests them without the intention of completing the course (Korn & Levitz, 2013a). Additional reasons for taking these classes include taking the course as a refresher, increasing knowledge, developing management skills, and, finally, gaining computer programming skills (Gose, 2012).

The instruction in MOOCs is often provided by *faculty with a reputation or expertise* in the topic of discussion, with many leading universities now offering these courses either independently or in partnership with a company (Vardi, 2012).

Faculty members in these courses serve as a coach or mentor in addition to guiding learners to embrace social media practices (Kop, Fournier, & Mak, 2011). As with traditional classroom-based instruction, faculty members often both design and lead the courses for the students who are enrolled (Hill, 2012).

With regard to instruction, MOOCs typically have somewhat *limited student interaction,* often including short videos of professors explaining course content, on-screen exercises and quizzes to provide reinforcement and keep students involved, and some form of social networking (Carr, 2012; Vardi, 2012). While the instructional materials often include a variety of media types, the communication exchanges between the professor and the students are often minimal (Gose, 2012).

Some MOOCs, however, are moving towards increased student interaction, focusing on open online student participation around a specific topic of interest (Kop *et al.*, 2011). Along the same lines, others are discussing the use of additional forms of current technology (multimedia, automated assessment, etc.) (DiSalvio, 2012) as well as a variety of additional course activities, such as lab experiments, discussion forums, case studies, etc. (Gose, 2012).

The final characteristic of MOOCs is the *low-cost budget model* for delivering these courses, a very important factor for higher education institutions (Vardi, 2012). The same factors that allow for this low-cost delivery in higher education (e.g., high enrollments) may also be appropriate for corporate training and development, with at least one author discussing the prospect of utilizing the MOOC model to offer standardized corporate-based courses at a low cost (Martin, 2012).

Carey (2012) discusses this overall cost model in some detail, describing how open-source textbooks and other free online resources help to lower the costs for MOOCs, also pointing out the low additional cost resulting from adding students to large existing courses. In addition, he discusses the more costlier aspects of MOOCs, including administering exams to students and providing one-on-one access to experts, with students potentially paying additional fees for these services.

MOOC Providers

The most prominent providers of MOOC-based courses include Coursera, edX, and Udacity, with all of these organizations having received external financing from organizations, including U.S. universities (Galagan, 2012; Hill, 2012). In addition to these formal providers, colleges and individual professors may choose to offer MOOCs on their own, or faculty members can sign up with Udemy, with revenues shared between the professor and this company (Mangan, 2012).

Coursera is one of the most popular organizations, having already enrolled more than two million students (Guthrie, 2012). Established by Daphne Koller and Andrew Ng (both originally from Stanford University's Computer Science Department), Coursera works collaboratively with 33 universities (including Stanford, Princeton, Penn, and the University of Michigan) to offer approximately 200 classes in a variety of academic disciplines (Carr, 2012). Courses offered by Coursera continue to attract significant interest, with 70,000 new students per week signing up for courses in areas such as human-computer interaction, songwriting, and gamification (Lewin, 2013).

The budget model for this organization is still evolving, with its revenue stream coming through specific course fees, licensing, certification fees, and the provision of student data to potential employers. Revenue from course fees is shared with partner universities which keep part of the revenue and a percentage of the gross profits. The production of these courses is relatively expensive, with each class costing approximately $50,000 and the largest expenses related to videography and compensating teaching assistants to monitor discussion forums (Lewin, 2013).

Another of the large MOOC-based providers is edX, developed jointly through Harvard and the Massachusetts Institute of Technology, who each provided $30 million for its creation (Lewin, 2013), with the University of California at Berkeley added to the consortium some time later. The organization offers tuition-free online classes mainly in math and engineering, utilizing video lessons and discussion forums, while also incorporating the use of virtual laboratories, where students can carry out simulated experiments (Carr, 2012).

While MOOCs have historically not provided course credits for their classes, edX has begun investigating this option through a pilot program in partnership with the Gates Foundation and the Massachusetts Institute of Technology. Through this collaboration, credits are provided to students at two community colleges who successfully complete specific classes taught via MOOCs supplemented with classroom instruction (Lewin & Markoff, 2013). Coursera is investigating similar credit-based options, with Antioch University's Los Angeles campus, offering students credit for successfully completing two Coursera courses, and the University of Washington offering credits for a fee in several Coursera courses, although only a few students actually have chosen this credit-carrying option (Lewin, 2013).

The final major player in the MOOC arena is Udacity, which was founded by Sebastian Thrun (also a former computer science research professor from Stanford) and others to provide courses where students learn by solving problems rather than simply listening to a professor talk about how to solve them (Hill, 2012; Mangan, 2012). Much like Coursera and edX, Udacity has been quite popular, bringing in $15 million in venture-capital financing as well as more than a million students interesting in taking MOOC-based courses (Lewin, 2013).

San Jose State University in California is one of the institutions working with Udacity, in this case collaborating to offer a series of remedial and introductory courses. This collaboration is somewhat unique, with professors from the University working with Udacity to create the courses and online course assistants or mentors hired and trained by Udacity providing support services for the program (Lewin & Markoff, 2013). Colorado State University is also working with Udacity, announcing that its online global campus will accept transfer credits from students who pass an introductory computer science course offered by Udacity if these students also pass Udacity's proctored exam (Mangan, 2012).

Potential Problems with MOOCs

While massive open online courses (MOOCs) have significant potential for educating large numbers of students in a variety of settings (higher education, high school, home, etc.), there have also been a number of problematic issues identified for this educational option. Understanding, and reacting appropriately, to these issues is critical to the successful implementation

of these courses, whether they are offered in relatively small settings or through large-scale systems with thousands of participants.

One of the major problems with this type of course, shared with some other types of online offerings, is the *high dropout rate* for students who start these classes. Carr (2012), for example, describes the Massachusetts Institute of Technology course on electronic circuits, as noted above, which originally enrolled 155,000 students, with only about five percent actually completing the course. The Artificial Intelligence class taught by Peter Norvig and Sebastian Thrun discussed above had similar issues, with only about 14 percent of the original 160,000 students actually completing the course.

The second major area of concern relates to the *financial model* utilized to offer these courses. In essence, while there is significant potential for attracting large numbers of students, universities still need to determine how to garner sufficient income from the delivery of these free or low-priced courses (Lewin, 2013). Charging students for credentials or selling lists of top-performing student to corporate recruiters are potential options for increasing revenue (Mangan, 2012), but these activities will work only for a subset of the total number of students taking these courses, and appear to be somewhat limited in terms of their potential to bring in significant revenue.

These suggestions for increasing the financial viability of MOOCs, however, are potentially overshadowed by parallel faculty issues, where these courses are often seen as a threat to professors jobs (Lewin & Markoff, 2013).

Credentialing, as mentioned above, is another area of significant concern for MOOCs. Snyder (2012) discusses this area of concern, describing some students who have little need for formal verification of their subject mastery but who enroll for personal improvement, although most students will potentially want some type of credentialing to indicate successful course completion. He goes on to describe the use of badges for students who complete these courses as well as the provision of university credit for students who complete a MOOC-based introductory computer science course at Colorado State University.

A final area of major concern is *academic integrity,* which is obviously also a problem for other types of online courses. Specific concerns in this general area include verifying that a student who is registered for a MOOC is the same person who completes the work, and the potential for widespread plagiarism on homework assignments. While there are potential solutions for these and other related issues through the use of honor codes, on-site testing, and other practices, this is an area where there are no easy answers for these difficult questions (Mangan, 2012; Snyder, 2012).

The Future of MOOCs

While there are clearly concerns about the use of MOOCs in higher education, there is also a growing feeling among many individuals that this type of coursework will significantly benefit students and academic institutions in the coming years. This perspective is supported by Lewin and Markoff (2013), who see MOOCs as rapidly moving from the periphery of higher education policy to its center, as an increasing number of colleges and universities investigate ways to offer these courses for credit toward a degree.

Carr (2012), for example, discusses how online instruction will change the nature of teaching on campus, making it more engaging and efficient, with MOOCs allowing large numbers of students to listen to lectures and work with related material on their computers via YouTube and other media delivery systems, then moving to classrooms to explore the content more deeply, known as the hybrid model.

This is clearly a potentially significant transition, but this type of change could also require having many labor-intensive tasks (e.g., grading tests, tutoring, etc.) to be carried out by computers, forcing many college administrators and professors to reconsider their assumptions about teaching.

This optimistic view is also supported by Carey (2012), who sees MOOCs as providing universal access to free, high-quality courses, accelerating the disintegration of the monopoly which colleges and universities hold over offering credits. While questions still exist related to the offering of credits as well as finance and quality assurance issues, this author describes accredited colleges working towards accepting MOOC certificates as transfer credit as well as significant interest by parents and students in credible low-cost options.

Friedman (2013) also supports this perspective, seeing MOOCs as a potential revolution in global online education, a way to reimagine higher education, and a possible method for lifting people out of poverty and providing them with an affordable education. Citing powerful stories about learners who have benefited greatly from this online platform, Friedman describes a future where students can create their own college degree by taking online courses from the best professors around the world, while paying only a small fee for certificates of completion.

Conclusion

With providers such as Coursera, edX, and Udacity working with high-quality academic institutions, including Stanford and the Massachusetts Institute of Technology, among many others, MOOCs have the potential to be significant providers of knowledge and skills to a wide variety of potential students. However, to truly become major players in the online and higher

education arenas, these massive open online courses must adjust their design and delivery systems to better match the current needs of students and to be more in line with traditional educational institutions, where students have their highest comfort level.

Along these lines, and in parallel with the issues developed earlier, Hill (2012) suggests the following strategies for MOOCs:

1. Provide an educational experience and perceived value that will help to enable higher course completion rates.

2. Develop revenue models that will make MOOCs self-sustaining.

3. Deliver signifiers of completion-such as credentials, badges, and acceptance into accredited programs.

4. Authenticate students so accreditation groups and potential hiring organizations are satisfied that a student's correct identity is known.

While there are still significant issues to be resolved with these new online systems, they clearly have the potential to change higher education in significant ways, while also providing high-quality education to the students who choose to learn through this type of system.

Only the future will tell us, however, whether this potential will lead to truly significant changes in online and traditional education, or instead, if MOOCs will become simply another useful technological option available for the benefit of learners and students everywhere. □

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Educational Technology Research Journals

Instructional Science, 2002–2011

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The authors analyzed all research articles published between 2002 and 2011 in the international journal *Instructional Science*, with a goal to provide an understanding of the type of research being published in this journal, major contributing authors, and the most-cited publications of this time period. They examined research methodology, recurrent keywords, major contributing authors, and citation trends of the articles. Over this 10-year period, they found a large increase in the amount of articles published per issue, a preference for inferential studies, a decrease in theoretical work, and an important emphasis on Cognitive Load Theory.

Introduction

Instructional Science is an international journal with a broad range of subjects and research related to teaching and learning. The Netherlands-based journal began publishing in 1972 and has since reached a global audience. P. M. Goodyear of Australia is the senior editor. Associate editors come from all parts of the world, including the Netherlands, France, Belgium, Israel, Singapore, Cyprus, and the United States.

According to the journal's Website, articles published in *Instructional Science* address varied topics and situations, including "learning by people of all ages, in all areas of the curriculum, and in informal and formal learning contexts." The journal places an emphasis on learning sciences, publishing articles on "learning processes, learning technology, learner characteristics, and learning outcomes." Preference is given to original empirical work, though review work is published as well. The journal states that it is unique in that it gives "space for full and detailed reporting of major studies." Overall, the aims of the journal are to promote "a deep understanding of the nature, theory, and practice of the instructional process and resultant learning" (*Instructional Science*, n.d.).

In this analysis, we examined articles published in *Instructional Science* in the years 2002–2011. Our goal is to provide an understanding of the type of research being published in this journal, major contributing authors, and the most-cited publications of this time period.

Methods

Of the 265 articles published between 2002 and 2011, 234 theoretical or empirical articles were analyzed. Thirty-one editorials, book reviews, special issue introductions, and commentaries were removed from the analysis. We conducted an analysis on trends in keywords, research methodologies, citations, and authorship.

Keywords Analysis

To understand trends in topical themes and common phrases used in *Instructional Science* from 2002 to 2011, we used author-provided keywords. Six articles in the decade under consideration did not provide keywords. In these cases, we included the subject terms provided by EBSCO. The words and phrases were compiled in a Microsoft Excel spreadsheet and organized by frequency. Subjects similar enough in meaning or connotation were combined into one word or phrase (e.g., Cognitive Load and Cognitive Load Theory), thus enabling more accurate identification of the most common topical trends in the journal over time.

Methodology and Article Types Analysis

Instructional Science publishes articles of varying methodologies and types. We established a basic system to code articles of different methodological types. First, we coded 20% of the articles as a team to establish consensus. The researchers then coded assigned articles separately. Another 20% of this individual work was double-coded by another team member for spot-check agreement. We maintained an 80% agreement threshold on double-coding. In cases of disagreement, discussion was held until agreement could be established. Articles where researchers felt uncertain about the coding were double-coded.

Articles were coded under the following categories:

- *Theoretical*—articles with little or no empirical intent, the primary purpose being to present and discuss theories, models, and technologies.
- *Inferential/Quantitative*—articles with a primary purpose of interpreting quantitative data from empirical research.
- *Interpretative/Qualitative*—articles with a primary purpose of interpreting qualitative data from empirical research.
- *Descriptive*—articles with a primary purpose of presenting descriptive statistics, often based on questionnaires.
- *Content Analysis*—articles with a primary purpose of categorizing written and recorded discourse and report descriptive findings.
- *Combined*—articles that combined methodologies to interpret and present findings.

Table 1. Keywords by number of times used.

Keyword	# of articles keyword appeared under
Cognitive Load	16
Computer-Mediated Communication	14
Collaborative Learning	12
Constructivism	12
Problem Solving	10
Problem-Based Learning	10
Higher Education	9
Learning	9
Epistemological Beliefs	8
Instructional Design	7
Science Education	7
Writing	7

Citation Analysis

We used Google Scholar to analyze article citation trends. All published articles, including editorials, were a part of this analysis. We feel Google Scholar provides an ample, comprehensive list on available scholarship. Other popular scholarship analysis tools, such as *Publish or Perish*, rely on Google Scholar. At the same time, some Google Scholar citation counts may not prove the most valuable. In addition, citation counts fluctuate over time. However, we feel this citation analysis still uncovers major contributions published in the highlighted time period.

Authorship Analysis

During the decade of 2002–2011, 498 authors published in *Instructional Science*, with the exclusion of authors of editorials, book reviews, special issue introductions, and commentaries. We analyzed these authors to determine major contributions to the field by quantifying who published the most articles. We also established a priority authorship count to determine contributions based on the order of the authors listed in the articles. First authors received three points, second authors received two points, and all subsequent authors received one point. Scores were tallied to create a list of priority contributions.

Findings

Keywords Analysis

Our analysis of the keywords in *Instructional Science* revealed an emphasis on cognitive load and constructivist learning models (see ***Table 1***). We also noted a significant presence of Problem-Based Learning (PBL), an increasingly popular learning model associated with Constructivism (Hmelo-Silver, 2004; Yew & Schmidt, 2011). Combining the number of keywords related to Constructivism and PBL reveals a significant emphasis on these themes in *Instructional Science*.

Occasionally, *Instructional Science* published a guest-edited thematic special issue. Recent issues have explored cognitive load theory, networked learning, and Web-based instruction. ***Table 2*** presents the topics and publication information of those special issues.

Table 2. Topics and publication information of journal special issues.

Topic	Year	Volume	Issue
Cognitive and Socio-Motivational Aspects in Learning with Animations	2010	38	5
Expertise Reversal Effect	2010	38	3
Effects of Constructivist Learning Environments	2008	36	5/6
Scaffolding Self-Regulated Learning and Cognition	2005	33	5/6
Cognitive Load Theory	2004	32	1/2
Web-Based Instruction	2003	31	4/5
Advances in Research on Network Learning	2003	31	1/2

Of the special issues, most noteworthy is the issue on Cognitive Load Theory. While cognitive learning methods are not explicitly a major part of the journal's target subjects, it can be inferred from the data that *Instructional Science* has played an important role in furthering research on such models. Articles in the 2010 issue on cognitive aspects of learning were cited more times than any other issue of the journal during the decade of consideration.

Methodology Analysis

From our analysis of research methods, we found inferential studies appeared most often, occurring, on average, 50% of the time (see ***Table 3***). Combined studies, followed by interpretative, were the next most frequently used research methodology, though not used as heavily as inferential.

While inferential studies consistently made up roughly half of the types of journals published each year, there was a notable decline in theoretical work and an incline in combined methods (see ***Table 4***). This trend of decreased theoretical work and increased inferential work has also been noted in a journal analysis on *The Internet and Higher Education*, done by Drysdale *et al.* (2013). However, a similar analysis on 10 journals in the field of instructional design and technology by West and Borep (in review) found a large percentage of theoretical work being published over a sample of 10 journals. This may indicate a preference change in only some journals, like *Instructional Science*, for less theoretical work, but not in the field at large.

While conducting this methodology analysis, it was also noted that the number of articles published in *Instructional Science* steadily increased in 2008. Between 2002 and 2008, *Instructional Science* published an average of 18 articles annually. This number rose from 23 in 2008 to 47 in 2011. This increase has also been noted in the 2012 issues.

Citation Analysis

Analysis of which articles are being cited the most each year across the decade reveals the international and far-reaching scope of *Instructional Science*. Interestingly,

Table 3. Research methodologies used by number and percentage.

Theoretical	Inferential	Interpretative	Descriptive	Content Analysis	Combined	Total Articles
7%	50%	12%	8%	9%	15%	234

Note. Percentages have been rounded.

Table 4. Most cited articles by year.

Year	Theoretical	Inferential	Interpretive	Descriptive	Content Analysis	Combined	Total
2002	5 (25%)	8 (40%)	2 (10%)	3 (15%)	1 (5%)	1 (5%)	20
2003	2 (14%)	3 (21%)	3 (21%)	3 (21%)	1 (7%)	2 (14%)	14
2004	3 (16%)	10 (53%)	0 (0%)	1 (5%)	3 (16%)	2 (11%)	19
2005	0 (0%)	8 (53%)	4 (27%)	1 (7%)	1 (7%)	1 (7%)	15
2006	2 (12%)	4 (23%)	2 (12%)	3 (18%)	4 (23%)	2 (12%)	17
2007	1 (5%)	9 (47%)	3 (16%)	1 (5%)	2 (11%)	3 (16%)	19
2008	1 (4%)	14 (61%)	1 (4%)	1 (4%)	1 (4%)	5 (22%)	23
2009	1 (3%)	17 (57%)	3 (10%)	2 (7%)	2 (7%)	5 (17%)	30
2010	1 (3%)	20 (65%)	1 (3%)	1 (3%)	1 (3%)	7 (23%)	31
2011	1 (2%)	23 (49%)	9 (19%)	2 (4%)	4 (9%)	8 (17%)	47

Note. Percentages have been rounded.

Table 5. Most contributing authors by total number of publications.

Year	Authors	Article Title	# of Citations
2002	M. A. Dahlgren & L. O. Dahlgren	Portraits of PBL: Students' experiences of the characteristics of problem-based learning in physiotherapy, computer engineering, and psychology	83
2003	M. Laat & V. Lally	Complexity, theory, and praxis: Researching collaborative learning and tutoring processes in a networked learning community	122
2004	F. Paas, A. Renkl, & J. Sweller	Cognitive load theory: Instructional implications of the interaction between information structures and cognitive architecture	286
2005	A. Weinberger, B. Ertl, F. Fischer, & H. Mandl	Epistemic and social scripts in computer-supported collaborative learning	229
2006	E. Zhu	Interaction and cognitive engagement: An analysis of four asynchronous online discussions	90
2007	M. D. Laat, V. Lally, L. Lipponen, & R. J. Simons	Online teaching in networked learning communities: A multi-method approach to studying the role of the teacher	82
2008	R. D. Roscoe & M. T. H. Chi	Tutor learning: The role of explaining and responding to questions	50
2009	M. M. Nelson & C. D. Schunn	The nature of feedback: How different types of peer feedback affect writing performance	48
2010	M. H. Lee & C. C. Tsai	Exploring teachers' perceived self efficacy and technological pedagogical content knowledge with respect to educational use of the World Wide Web	49
2011	D. Ifenthaler, I. Masduki, & N. M. Seel	The mystery of cognitive structure and how we can detect it: Tracking the development of cognitive structures over time	25

the top articles for each year are somewhat disconnected from one another, except for three articles related to cognitivist theory, which were the top articles in 2004, 2006, and 2011 (see ***Table 5***).

Though editorials were not a part of our sample, it is interesting to note that in 2004 the top-cited article was not a research article but an editorial on Cognitive Load Theory. More importantly, this same article is cited more than any other article for the entire decade and is related to the most often used keyword in *Instructional Science*.

Authorship Analysis

Of the 234 articles published between 2002 and 2011, we found a high number of co-authorship: 84% of those articles had more than one author. Looking further, 49% of the total number of articles published had at least three authors. These findings make sense when considering the number of empirical studies published in this journal, and the amount of people and resources needed to complete these studies.

Most authors have published only once in Instructional Science, though a number of authors have published more. ***Table 6*** indicates the most published authors of *Instructional Science* during this decade.

While this list indicates some of the top-contributing authors to this journal, we feel that the priority authorship analysis is more telling, as it examines authorship rank. ***Table 7*** details the findings of that analysis.

While van Merriënboer had authored the greatest number of articles, he never was listed above a third author. Pang and Hew were the highest counted first authors, having published three articles as first authors. Renkl and Tsai both received the highest priority points, having been listed a number of times as second author or greater. This coincides with the publications list, where Renkl and Tsai are both shown as high-publishing authors. Renkl's most cited article was "Cognitive Load Theory: Instructional Implications of the Interaction Between Information Structures and Cognitive Architecture," which he co-authored as a second author with Paas and Sweller (2004). This was the top-most cited article in *Instructional Science* between 2002 and 2011. The article was a special issue introduction on cognitive load theory, and presented the current research trends of the theory as well as a continued discussion of the theory. Tsai's most cited article was "Exploring Teachers' Perceived Self Efficacy and Technological Pedagogical Content Knowledge with Respect to Educational Use of the World Wide Web," which he co-authored as second author with Lee (2010). This article is listed as the most cited article in 2010. In "Exploring," Lee and Tsai investigated teachers' perceived self-efficacy in relation to using the Web as a means of instruction. The authors developed a survey grounded in Technological Pedagogical Content Knowledge theory, which they administered to 558 instructors. The study found that older instructors tended to have the lowest reported feelings of self-efficacy.

Discussion

In reflecting on the overall trends and significant findings in our analysis, we discovered that *Instructional Science* is producing significantly more articles than in the past. A great majority of the articles published were done collaboratively. Themes such as Cognitive Load Theory, Problem-Based Learning, and Constructivist models have been prevalent topics. The most-cited article in this journal was Paas, Renkl, and Sweller's (2004) theoretical editorial on cognitive overload. We highlighted a significant preference for inferential studies, and noted a rise in combined methods and a decrease in theoretical work. This may be a publication preference, but it may also reflect a rising trend in our field for more empirical research. However, this trend may indicate a future need to reemphasize the other methodologies, particularly theoretical work, as theoretical work can inform practice. Burkhardt and Schoenfeld (2003) stated, "Education lags far behind in the range and reliability of its theories" (p. 10), which would present an argument for the need for additional theoretical work to advance the effectiveness of our field. □

Table 6. Most contributing authors by total number of publications.

Total Publications	Author
9	Jeroen J. G. van Merriënboer
7	Alexander Renkl
5	Chin-Chung Tsai & Fred Paas
4	Lucia Mason, Ming Fai Pang, Henk G. Schmidt, & John Sweller
3	Tessa H. S. Eysink, Peter Gerjets, Wim H. Gijselaers, Michael J. Hannafin, Khe Foon Hew, Ton de Jong, Gellof Kanselaar, Manu Kapur, Sari Lindblom-Ylänne, Ference Marton, Katharina Scheiter, & Keith Trigwell

Table 7. Most contributing authors by priority count totals.

Total Points	Author
11	Alexander Renkl, Chin-Chung Tsai
10	Lucia Mason, Fred Paas, Ming Fai Pang
9	Jeroen J. G. van Merriënboer, Khe Foon Hew
8	Manu Kapur
7	John Sweller, Peter Gerjets, Sari Lindblom-Ylänne, Tessa H. S. Eysink

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Q & A with Ed Tech Leaders

Interview with Stavros Demetriadis

Susan M. Fulgham
Michael F. Shaughnessy
Contributing Editors

1. What are you currently researching?

Three topics attract my research efforts currently:

1. *Adaptive systems for collaborative learning.* This refers to building technologically flexible systems for offering personalized and pedagogically appropriate support to groups and individuals within learning groups.
2. *Scripting collaboration in computer-supported collaborative learning (CSCL).* I am interested in developing digital tools for scripting (guiding and structuring) the collaborative learning activity and exploring their impact at many levels (affective, cognitive, metacognitive).

Stavros Demetriadis *is currently an Assistant Professor with the Department of Informatics, Aristotle University of Thessaloniki (AUTh) in Greece. He also earned his Bachelor's degree in Physics and a Master Diploma in Electronic Physics from AUTh. He became interested in information and communications technologies when he was a high school Informatics teacher, and returned to the Department of Informatics, AUTh to earn his PhD in Multimedia Technology in Education. Dr. Demetriadis's major research interests are related to adaptive systems for collaborative learning, technology systems for scripting in CSCL, and collaborative techniques for advancing young learners' computational thinking skills (e-mail:* ***sdemetri@csd.auth.gr****)*

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3. *Advancing students' computational thinking.* Computational thinking involves skills that relate to students' ability to analyze and represent problems and their solutions in ways that are processable by a digital machine. The concept is not new (Papert introduced it in the 1990s) but there is a renewed interest linked also to the fact that educators now have many tools for introductory and "recreational" programming (for example, robotics, tangibles, Scratch, Alice, LookingGlass, GameMaker, and others), and engaging kids in such activities is easier than ever before. Our interest is on empowering teachers with appropriate intervention techniques (for example, collaboration scripts and prompts) to maximize students' computational thinking skills.

2. You have recently published material on group formation based on learning styles. What instrument did you use and what were the results?

In exploring group formation based on students' learning styles, we developed and used the PEGASUS system (PErson-centered Group-Activity SUpport System). The system identifies students' learning styles using the Raudsepp Problem Solving Styles Inventory and then assigns students to heterogeneous groups (3, 4, or 5 members in group). Heterogeneity refers to having in the same group students of different learning styles. It is expected that this arrangement causes productive imbalance in the group, which may lead to students' greater satisfaction, as they can be assigned tasks within the group which are better fitted to their own styles.

In our work, two major conclusions were recorded: (a) the adoption of learning styles theories in practice can be greatly facilitated by systems for automated group formation—otherwise the daunting task of identifying styles and making necessary group arrangements may disappoint the interested teachers; and (b) group formation methods aided students by emphasizing complementarities and pluralism in ways of thinking, but only after the instructors' consistent support through regular group-facilitation meetings. Otherwise, using the learning styles-based grouping may result in a trivial approach of using styles to simply "label" students.

3. What do you mean by scripted collaboration, and how would it work?

"Scripted collaboration" refers to scripting (structuring and guiding) students' activity within learning groups Scripting is important as it triggers peer interactions (for example, engage peers in argumentation, conflict resolution, reviewing each others' work, etc.), which otherwise would not have happened. Productive peer interaction, in turn, leads to improved learning outcomes (both domain-specific and domain-general). Practically, the idea of scripting boils down to three specific prescriptions for instructors:

1. *Structure group work in distinct phases.* In each phase it should be clear what the group work is and the kind of deliverables it leads to.
2. *Assign roles to students in each phase.* Provide adequate guidance on how to play each role. Playing a role offers an excellent opportunity to trigger peer interaction.
3. *Define deliverables.* Each work phase should lead to developing a deliverable, which should be the outcome of role playing and peer interaction.

In technology-enhanced learning (TEL), interest in the idea of scripting has led to the development of integrated environments and specific digital tools that support both teachers (as script designers and orchestrators of the collaborative activity) and students (as active learners engaging in interactions prescribed by the script).

4. What do you mean by peer review based scripted collaboration, and how would it work in real life?

"Peer review based scripted collaboration" refers to engaging students in collaboration based on a peer review scenario. Typically a peer review learning activity implements an "assigned pair" protocol, which means that the teacher assigns student work (e.g., essays) for review by student pairs. However, this allows students to review only one of their peer works and accept review from only one of their peers. To improve the situation, we have proposed and explored the impact of a "Free-Selection" protocol (students are allowed to freely explore and select peer works for review). Our results indicate that students following the Free Selection protocol demonstrate (a) better domain learning outcomes, and (b) better reviewer skills, as compared to the Assigned Pair condition. You need some kind of technology to efficiently implement the technique, but it can be as simple as a Webpage, where peer works would be available for preview and downloading.

5. How do you define domain-specific and domain-general knowledge? And how does this relate to knowledge acquisition in computer science?

Knowledge and skills relevant to the domain of instruction are always "domain-specific." For example, understanding the basics of computer networking is conceptually domain-specific knowledge in the computer science area. "Transversal" knowledge/skills not directly relevant to the domain of instruction but used as a means for instruction can be described as "domain-general." For example, understanding argumentation and constructing good arguments about building an efficient computer network can be considered as a domain-general knowledge when learning about networks.

6. You recently reviewed the field in terms of "adaptive and intelligent systems for collaborative learning support." Could you summarize what you found?

Adaptive and intelligent systems are important because—at least in theory—they integrate teacher expertise and can guide students efficiently, providing appropriate support at the time it is needed. We reviewed 105 relevant articles, with 70 of them reporting concrete evaluation data on the learning impact of adaptive/intelligent systems for collaborative learning. The reviewed articles indicate that such systems increasingly introduce artificial intelligence and Semantic Web techniques to

support various phases of the collaborative activity; for example, guiding group formation and facilitating learning by triggering peer interaction.

Our findings suggest that systems can improve both learners' domain knowledge and collaboration skills; however, these benefits are subject to the learning design and the capability of the system to adapt and intervene in an unobtrusive way, thus avoiding increasing learners' cognitive load.

7. What is an "adaptation pattern"? What is adaptive collaborative learning activity?

Adaptation patterns are primitives of teachers' adaptive behavior when guiding small-group work. In other words, adaptation patterns are prototypical ways of changing/adapting one's initial design (course of action) when specific conditions are encountered. Think of a teacher who directs students to work in small groups following initially a specific didactic scenario. At a point he or she realizes that a more advanced/skillful student in a dyad has already completed the task while a partner struggles to follow. How does the teacher adapt the initial task design to keep the advanced student engaged and benefit also the less capable? We analyze what the teacher thinks as a good adaptation practice in this situation, and we classify this teacher's intervention as an adaptation pattern in the context of collaborative learning. We have managed so far to identify several such patterns, formalize them, and integrate (some of them) in technological environments for collaborative learning. We consider this a promising path that may lead to advanced adaptive/intelligent tools for supporting collaboration.

8. What patterns of modeling have you found to have a practical influence when designing modules for learning?

Based on our analysis of adaptation patterns, I can argue that important learners' profile aspects that need to be modeled include:

(a) *students' prior domain knowledge:* this is typical modeling in many adaptive systems, helping to make the system aware of the "learning starting point" for any specific student;

(b) *students' experiences with collaborative learning activities and techniques:* this would help adapt the scaffolding interventions of the system and the roles assigned to the students—for example, a more experienced student could be assigned the group moderator role; and

(c *group synthesis:* modeling the group as a whole helps modeling the possible dynamics of peer interaction and thus adapt the level of guidance provided to the group and individuals; for example, it is different to have two domain novices working together (you need to provide consistent support) than having a dyad with a novice and an advanced student (the collaboration script can be adapted so that the advanced works on a more demanding version of the task, supporting also the novice during collaboration).

9. Many students have quite different learning styles—how can prompting and encouragement help?

We came across this issue in one of our studies exploring the impact of question prompts on student learning in relation to their learning styles. The students' styles were modeled according to Kolb's learning styles inventory (accommodator, assimilator, converger, and diverger) and the prompting technique helped students focus on important issues while working to analyze cases in the domain of software project management. Our results indicated that convergers considered the question prompts as more helpful and less tiresome than the other student styles, being also the group that provided the longest and, seemingly, more complete answers to the prompts during their study. It is possible, therefore, that although prompting can be generally helpful, factors such as the students' learning styles are able to limit the cognitive benefit emerging from the prompting intervention. The suggestion for designers is to consider combining prompting with other scaffolding methods, in order to effectively support all students, independent of their learning styles.

Our current understanding, however, considering students' learning styles, is that students' self-awareness of possibilities and limitations regarding their own styles is of primary importance in learning situations, and it can be effectively supported through teacher–group face-to-face supportive sessions (group-facilitation meetings).

10. Could you describe further your use of PEGASUS and how this would help with supporting group activity??

The PEGASUS system can actually do three things:

(a) allow students to login to the system and answer a learning style psychometric test;

(b) process students' answers and identify their learning style, providing also initial information on strong and weak points regarding student style; and

(c) allocate each student in a student group depending on the instructor's group formation settings (for example, a teacher may ask for heterogeneous quadruplets and thus PEGASUS provides a possible four-member grouping, satisfying the heterogeneity criterion).

In essence, PEGASUS (as other similar technologies) is a learning style-based group formation system that automates the daunting task of group formation and makes it much easier to accomplish for the instructor. This step (group formation) is a first important step in applying learning style-based pedagogy. However, as I discussed earlier, the effectiveness of a learning-styles approach strongly depends on teacher–group face-to-face interaction, which should cultivate students' self-awareness of their styles and boost group creativity.

11. What do you mean by an "ill-structured" domain, and how does the prompting mode affect learning?

Domains can be classified as more or less well- (or ill-) structured. In an ill-structured domain, the context of a situation when knowledge is applied has a strong influence on the problem-solving process and the possible solutions.

Thus, the domain cannot be studied through an abstraction approach that eliminates contextual factors and provides solutions in a "linear" fashion (i.e., that the same initial conditions imply the same solution). Instead the context has to be thoroughly analyzed and taken into consideration during the solution process. Such domains include applied medicine, law, and management (such as software project management and others), and instruction needs to employ methods sensitive to contextual factors, such as case-based learning.

In case-based learning, prompting techniques can serve many purposes—cognitive and metacognitive. While students are guided to study a number of relevant cases, prompts attract their attention to the varying roles and impacts of contextual factors, help them reflect on the intricacies of applying domain knowledge during problem solving, and facilitate metacognitive processes.

In our research, we have explored the effectiveness of two variants of a prompting strategy, when students learn in an ill-structured domain with the aid of a Web-based environment. Specifically we investigated the impact of the "writing mode" (students are asked to provide written answers to a set of prompts meant to engage them in deeper processing of the material) vs. the "thinking mode" (students are asked only to think of possible answers to the same question prompts). Results indicated that students in the "writing" condition group outperformed the "thinking" condition group in both domain knowledge acquisition and knowledge transfer post-test items. The conclusion is that prompting techniques may lead to improved outcomes, when combined with the requirement that students provide their answers in writing.

12. What should designers look at when deciding at what point in the learning to fade prompts? When does the prompting interfere with learning?

The answer to this (when to fade out scaffolding) is not straightforward. It depends on contextual factors, such as the complexity of the script to be internalized and students' prior knowledge/skills. However, what is important is that when fading out, the system should also engage students in practicing the skills to be learned. Simply fading out the support does not seem to provide any benefit.

13. How do you define "novice student learning" as opposed to "expert student learning," and how should we be studying this—qualitatively or quantitatively?

"Novice student learning" refers to the three lower levels of Bloom's learning taxonomy (that is, recalling basic domain information, understanding the introductory domain conceptual framework, and being able to supply basic domain problem-solving techniques). Respectively, "advanced (or 'expert') student learning" focuses on the three higher levels of the hierarchy, that is, to learn and be able to analyze complex problem situations, design or synthesize appropriate solutions based on the analysis of a complex situation, and evaluate various proposed solutions.

Both quantitative and qualitative methods can (and should) be used for studying novice and advanced level learning. However, as the latter is evidenced in complex learning activities (such as, for example, project-based learning), it is important that the researchers apply a battery of research techniques, which combined can document the emergence of student advanced mental models.

14. What are "e-lectures" in your mind, and how would you study their efficiency? Why are they important?

I call an "e-lecture" the very common practice, nowadays, to upload digitized versions of course lecturing material as supportive learning material for students. An e-lecture can be developed "in vivo" (the instructor is lecturing in front of a live audience) or "in-vitro" (the instructor is lecturing in studio conditions addressing a virtual audience). E-lecturing is obviously important because it helps to increase the flexibility of the learning experience. At the same time, however, it is important that the adoption of e-lectures to support flexible learning should be advanced in close relationship to models of course re-engineering that also foster instructional cohesiveness, by integrating the various learning events as interrelated nodes of a productive learning network. In other words, e-lecturing should be part of an integrated strategy that encourages and advances student engagement and efficient learning in parallel with increasing flexibility in educational settings.

15. Could you discuss the value of "writing to learn" and it's importance?

Several authors have emphasized the learning benefits emerging for students when practicing writing-to-learn activities, suggesting that the process of eliciting thoughts in written form enhances the thinking process and learning outcomes. Relevant research has shown that writing can be used effectively as a tool for constructive learning and for supporting students in developing critical thinking and increasing their analysis, inference, and evaluation skills.

In line with this perspective, we have investigated how student prompting techniques embedded in technology-enhanced learning environments can have an increased impact on learning in ill-structured domains. In particular, we developed a Web environment for case-based learning, where students were prompted to (a) focus on the role of key events in the case, (b) relate these events to what is already known from other similar situations, and (c) reach useful conclusions (reasoning process), based on the results of the two previous steps.

Our results indicated, as also mentioned earlier, that asking students simply to think of possible answers to the above prompts was not as engaging and effective as when asking for submitting written answers. We concluded that eliciting thoughts in written and properly phrased statements and arguments triggered additional cognitive activity that resulted in better learning outcomes. The implication for designers is that interactions for having students express in writing their thinking during the learning activity can be a more effective option in technology-learning environments compared to simple question-answering techniques.

16. In your country, are you "going blended" or

approaching learning from some other perspective?

As in many other countries, "going blended" in Greece is not exactly the mainstream course of action but the practice of more skillful and experienced educators and in specific situations. "Going blended" may refer to (a) combining onsite (face-to-face) and online (Web-based) learning activities, and you can see this happening in certain cases, for example, in inservice teacher training seminars, and (b) teachers integrating digital technologies in their everyday practice; tools like interactive boards, multimedia content repositories, Internet resources and also—more rarely though—social networking media.

17. Who has mentored or influenced you?

One of my first influences was Michael Jacobson (currently at the University of Sydney), whose work on hypertext and cognitive flexibility theory inspired my PhD work. I closely attend the work by colleagues in the CSCL and adaptive/intelligent systems community, including (in the US) Peter Brusilovsky (University of Pittsburgh), Carolyn Rose (Carnegie Mellon), and Dan Suthers (University of Hawaii at Manoa), and (in Europe) Pierre Tchounikine (University of Grenoble), Pierre Dillenbourg (EPFL), Frank Fischer (University of Munich), Armin Weinberger (Saarland University), and, of course, my dear friend Yannis Dimitriadis (University of Valladolid).

18. What is your educational background and your experience in the field of educational technology?

I entered the Aristotle University of Thessaloniki (AUTh) in 1978 to study Physics. At that time the term "educational technology" referred to using overhead projectors—perhaps also videotapes—in the classroom! The computers available were mainframe systems, where programming was done using punched cards and—if you were lucky enough—dummy terminals. I took my first courses on programming (Fortran and Pascal) during my basic studies and after getting my diploma I enrolled in a two-year postgraduate program in electronic physics, where I specialized in microprocessors and assembly programming,

Having a postgraduate degree, it was rather easy to get a job in education, so I joined secondary technical education as an electronics teacher (1989). In the meantime, the first personal computer laboratories were installed in Greek technical schools, and there was a need for computer-specialized teachers.

As a teacher, I grew up interested in using digital technology for educational purposes and in doing research in the field. The opportunity was provided a few years later (1994), when I joined the newly established (1992) Department of Informatics at AUTh as an adjunct researcher. The department had just installed a very well equipped multimedia laboratory, where I could do research on the educational use of multimedia technology. Soon, I discovered a lot about learning theories, instructional design, and multimedia authoring tools of the time, like Authorware, Director, and Toolbook. My PhD work was decisively influenced by the work of Rand Spiro and Michael Jacobson in cognitive flexibility theory and hypermedia applications for learning in complex domains.

I developed a software application for case-based learning in the computer networking domain and demonstrated how novice learning by criss-crossing the domain could be significantly more flexible when compared to learning following the typical method of linearly covering the thematically organized domain. I published my first journal papers and did my first conference announcements on this issue and got my PhD in 2000. Later on (2002), I joined the department as a Lecturer (2002–2008) and Assistant Professor (2008–now). Early in my academic career I had the very constructive experience of leading the AUTh team participating in the "Kaleidoscope" European Network of Excellence.

19. Please describe the university with which you are affiliated.

The Aristotle University of Thessaloniki (AUTh) (*http://www.auth.gr*) was established in 1926 and is the largest university in Greece and the Balkans (more information on AUTh history can be found here: *http://www.auth.gr/en/history*). AUTh comprises seven Faculties organized into 33 Schools, five single-School Faculties, as well as four independent Schools. The University campus covers some 23 hectares close to the center of Thessaloniki, but some educational and administrative facilities are located off-campus for practical and operational reasons. A number of those are outside Thessaloniki or even in other cities. More than 95,000 undergraduate and postgraduate students study at AUTh (55,000 active students), 86,000 in undergraduate programs, and 9,000 in postgraduate programs. The faculty members (Teaching and Research Staff) number 2,316 people (648 professors, 620 associate professors, 502 assistant professors, and 546 lecturers).

The Department of Informatics (*http://www.csd.auth.gr*) was established in 1992 as a part of the Faculty of Sciences of AUTh. There are about 700 undergraduate students enrolled, 140 graduate students in two postgraduate courses, and 100 PhD students. The faculty members are currently 30 and there are five research laboratories in the Department: (1) Multimedia Laboratory, (2) Computer Architecture and Communications Laboratory, (3) Artificial Intelligence and Information Analysis Laboratory, (4) Data Engineering Laboratory, and (5) Programming Languages and Software Engineering Laboratory.

The activities of the Multimedia Laboratory focus mainly on the domain of educational technology (some other domains are also supported within the lab). Research and instruction are oriented to the design, development, and evaluation of technology-enhanced learning environments, with emphasis on computer-supported collaborative learning, instructional design, flexible learning, multimedia/ hypermedia learning applications, intelligent agents for learning, learning communities, and the didactics of informatics.

20. What is the current status of the educational technology field in Greece?

In Greece there is currently a relatively small but active educational technology community. The community is offi-

cially represented by "ETPE," which is the "Greek Scientific Association for ICT in Education," with 355 members currently (est. 2000; *http://www.etpe.gr/index.php* . Unfortunately, the site is temporarily available only in Greek).

Technology-enhanced learning (TEL) was advanced in Greece during the 1997–2001 years when major investments in infrastructure (through a panhellenic project under the code name "Odyssey") helped via installing computer laboratories at secondary education schools; made available to schools several successful software learning tools (most of them translated in Greek); and organized ICT-in-classroom training seminars for inservice teachers.

Today, although computer equipment can be found in many schools, there are two major drawbacks for TEL activities: (a) it is difficult for schools to update their software and hardware infrastructure, and (b) it is difficult for teachers to have the necessary technical support. However, as new teachers (familiar with the use of technology) enter the profession and technological tools mature (thus are more reliable to use) many more TEL activities are conducted in schools, employing current technologies that greatly attract the interest of students, such as Web 2.0 communication services for supporting school communities and programming tools for educational robotics. Most of these pioneering teachers are usually university masters or doctoral students, who implement in their classrooms innovative teaching methods and present their results in national and international fora.

Members of the Greek educational technology community are actively participating in the committees of many conferences worldwide (for example, the IEEE ICALT conference, CSCL, INCoS, Constructionism, etc.). The community issues the international refereed journal *Themes in Science and Technology Education.* Several conferences of interest (national and international) are organized in Greece each year. Some of these focus strongly on the work done by teachers at schools (such as the conference organized in Syros island each year, the conference on the Didactics of Informatics, and the conference of Computer Science teachers). And at least one international conference (the ICICTE conference) is permanently organized in Greece, in picturesque locations, such as the Corfu, Rhodes, Crete, and Samos islands.

21. What have we neglected to ask?

People often ask (or wonder) if investments in educational technology actually pay back. I always answer that the impact of learning technology can be profound and can only be appropriately evaluated in the long run. Learning is a complex phenomenon, interweaving psychological, social, and cognitive factors. Technology opens new roads and possibilities and offers the opportunity to our students to engage in rich learning experiences, making them "richer" people cognitively, metacognitively, and socially. However, teachers should always keep in mind that for students the sense of belonging to a learning community and the face-to-face communication with the teacher (as an expert member of the community) are irreplaceable. □

Educational Technology Classics

The Future for Education and Educational Technology: What Is the Question?

Robert J. Seidel

Often when we consider the problem of education today, those of us in the educational technology field are very quick to point out that there are many indications of failure of the system as it exists.

For the moment, however, consider the alternative possibility, not that education has failed, but that we have failed to take adequate accounting of the societal characteristics surrounding the educational system which may have created the difficulties.

Let's ask the question to begin with: what hard data exist to tell us that the educational system has failed? I know of no experimental findings that indicate a failure on the part of the educational system.* The data that we might look at indicate perhaps that there are some dropouts. The data also indicate that there may be student riots and widespread disruption on the part of the potential learner.

But consider the following premise. For many, many years it has been noted that schools have taken on the role of surrogate parents; they have done so because the parents have abdicated their responsibilities for nurturing the social development of the child. Could it not be that what the students are rebelling against within the school

This article appeared originally in this magazine in July, 1971. The author, ***Robert J. Seidel****, at that time was Program Director, Instructional Technology, at the Human Resources Research Organization, Alexandria, Virginia.*

* On the contrary, see, for example, Harman's overview of illiteracy (*Harvard Educational Review, 40*(4), May 1970). The appendix to his paper demonstrates a universal trend by states towards deceasing percentages of illiteracy from 1900 through 1930 and 1960 in the United States. One criticism of such data is that no single acceptable set of criteria exists for defining literacy. However, this must be counter-weighted against the fact that reporting procedures have been increasingly refined over the years. Thus, if any reversal in trend were to be found, it would be more likely to appear in recent years.

system is that it has not been fulfilling the role of surrogate parent adequately? Consider also the other possibility, that what has really disrupted the students is not so much the school or educational system per se, but the society that surrounds it, and that the institution against which students can make their protest most readily felt is the institution within which they spend something on the order of six to eight hours a day, most of their waking day!

I suggest that the reader consider this in light of other characteristics of a society with increasing complexities, increasing technology, yet with problems not adequately defined within the subsystem of education—which is found too readily as a handy whipping boy or scapegoat.

As I said, I would still like to see some hard data indicating the failure of the educational institution. To my mind, most of the data that we cite are soft and are potentially contaminated by other characteristics of our society.

Another feature of the discussion to consider is the criticism that has been raised from time to time, more vocally recently on the part of many free-schoolers: that educational technology is really a way of being concerned with more efficient means without any consideration of the *end* which these means might serve.

Indeed, we in this field today, considering the need to re-examine national goals, particularly as they pertain to the forthcoming establishment of a National Institute of Education, ought really to consider what contributions we might make towards shaping those ends towards which this field of education and educational technology are directed, as well as considering the means for satisfying them. And once we have considered this particular point in some detail, we might also consider how we might go about evaluating these national goals, which we establish as objectives of the educational system to be enhanced by the field of educational technology.

Certainly in view of the commentary about evaluation and the need for specifying criteria objectively, one could make the case that in the area of training or career planning in particular, education in a restricted sense of the word might well be outmoded or at least will soon become obsolete (e.g., 80 percent novelty in job structure for the next generation). But whether or not this holds for the entire field of education is subject to serious question.

Silberman (1970, p.17) illustrates this question rather nicely by citing, as he calls it, "the great polemic of 1930" by Abraham Flexner on the state of the university in the United States, in which he deplored the degrading or deteriorating quality of the Ph.D. He wrote that at that time it had diminished to the level of practically no significance. As Silberman points out, when Flexner wrote, 5 percent of the Nobel Prizes were held by Americans, yet today the figure is beyond 40 percent. The point to note here is that Flexner was a well-known critic at the time of his polemic.

Moreover, persons who agree with his point of view were certainly sincere in their feelings about the deficiencies of American education—just as today we are sincere in our high feelings concerning deficiencies in American education. We still must ask the question, what kind of evidence is available to justify these feelings, other than our own subjective opinion? Apparently, the number and quality of critics is not a sufficient basis upon which to draw the conclusion that something is drastically wrong with education.

Again, Silberman (1970, p. 18) notes that, contrary to some popular impressions, the so-called dropout rate in high school is declining. While the proportion finishing high school is currently 75 percent, it is expected to reach as high as 85 percent by the mid-1970s. In fact as a colleague has noted, one could even make a reasonable case for asserting the fantastic success of the education system because of the rioting, disruption, etc.

If one considers that education has as a goal inquiry, questioning, and general exploration of alternative ways of upgrading the society, then we might readily assert the above proposition. As John Stuart Mill put the question on independent thinking:

> Whether our "march of intellect" be not rather a march towards doing without intellect, and supplying our deficiency of giants by the united efforts on a constantly increasing multitude of dwarfs…Where, then, is the remedy?…It is in the distinct recognition that the end of education is not to teach, but to fit the mind for learning from its own consciousness and observation…
>
> (from *On Genius*, 1832)

The ultimate point: viz, the "success" of the education subsystem may be that, given its success to date, it may well have *led* society into an obsolescent state. It thereby will have to lead society again, this time into the 21st century; and the type of education system appropriate for leading in the 1920s, '30s, etc., will have to evolve into a more appropriate structure if it is to accomplish the job. The question then becomes, what must the structure be?

There are hints and fragmented probings now; e.g., accountability projects (highlighted recently in *Educational Technology,* January, 1971), isolated introduction of computer usage in various ways (for parts of instruction and as a curricular topic), use of criterion-referenced testing (an outgrowth of PI and task analysis), IPI, etc.

But what is required is a well-coordinated, systematic, evolutionary attack on the goals and nature of the education subsystem as it fits into the perceived shape of other societal subsystems (politics, family, economics, etc.) in order to result in a viable 21st century model for the continuing development of man. What is needed is an increasing number of well-conceived plans with productive promises within which a new, viable 21st century model can emerge. □

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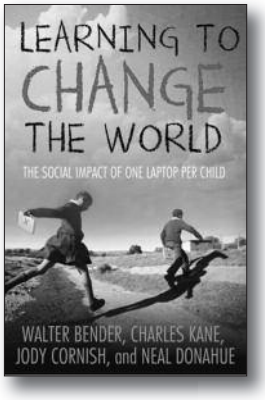
Book Reviews



Are We Learning to Change the World?

Book Review: Walter Bender, Charles Kane, Jody Cornish, and Neal Donahue. ***Learning to Change the World: The Social Impact of One Laptop Per Child.*** *Palgrave Macmillan; 246 pages; 2012; $28.00.*

Reviewed by Curtis J. Bonk

Introduction to This…"Book"

This is not simply a book. It is actually a social movement and a paradigm for educational change. At its core are the principles and ideas espoused by many of the people discussed in this book. While the authors lay out a fairly thorough analysis of the One Laptop Per Child (OLPC) project and resulting XO laptop and Sugar software platform, they do not conclude whether that project has been a success or not. Instead, they document the constant struggles of innovation within the OLPC project. As such, it is not just a story focused on individual learning with child-centered technology, but one that highlights unique business practices, including those related to marketing, supply chain management, finance, leadership, and innovative engineering and design.

If this is a book, it is simultaneously a history book, a project management guide, a tale about innovators in a technology start-up, and a philosophical doctrine for educators hoping to inspire disenfranchised youth. It might also be considered a casebook related to technology integration. Suffice to say, there are countless lenses or viewpoints to take, including that of educator, government contractor, community organizer, and technology innovator.

The chapters of this book are filled with the hope of a better tomorrow but are situated in the hard social realities and tensions of educational reform today. There is a tension between student performance goals to which schools are held accountable (e.g., reading and math scores) and life skills that children desperately need (e.g., creative problem solving, critical thinking, etc.). There is a tension between urban and rural deployment of the XO. And a tension between top-down and bottom-up approaches to buy-in for such a product.

There is a tension between dropping XOs in the hands of students for their self-directed exploration and the clamoring for teacher training in innovative pedagogy related to these machines.

Finally, there is a tension between designing a computer for child-centered learning and the difficulties innovators face when attempting to change the entire ecosystem of schools. Given such tensions, dive into any chapter of *Learning to Change the World* and the stories and reflections you will discover are bound to arouse your interests. You will quickly realize that true progress requires many ingredients.

Pointing Back to Papert

As such, *Learning to Change the World* is a momentous reflective moment in the field of educational technology, including the history of personal computing and the shift from instructor- and text-centered learning to "constructionism." As a history book, it should enlighten graduate students and others new to the field about the incremental evolution that has brought us to a more learner-centered educational age here in 2013. Learners today generate ideas instead of passively consuming them, just as Seymour Papert of the MIT Media Lab long ago predicted, including an article in this magazine in 1971.

Unfortunately, too many students enrolled in educational technology programs today have never heard of Seymour Papert and his ideas about personal computers as tools to think with. Papert's vision for a world filled with learner experimentation and hypothesis generation is embedded throughout this book. As someone who went to graduate school at Wisconsin in the late 1980s, where Papert's widely acclaimed book, *Mindstorms: Children, Computers, and Powerful Ideas,* was required reading, this book brings back fond memories. Ironically, a month after reading Papert's book, I heard him speak at the World Congress on Education and Technology back in May 1986 in Vancouver and then again at his Media Lab four years later. Clearly, the OLPC project took Papert's experimental ideas from the Mid-1980s and early 1990s in Boston and extended them to the far reaches of the world.

Given this backdrop, rich with grandiose hopes and huge expectations, the results shared in this book related to the OLPC were at times amazing and at other times highly disappointing. In many ways, the various constructionist principles and activities that are embedded throughout the book predate the Web 2.0 and associated participatory learning ideas in vogue today. At the same time, they are also enhanced by this highly powerful Web age. The instantaneous global collaborations that are possible online with a laptop or set of laptops were mere dreams for most educators and students working with Papert and other learning technology leaders back in the 1980s. Today they happen in remote villages of Cambodia as well as the schools throughout Paraguay, Uruguay, and Nigeria.

Clearly, Papert was not operating alone in his media lab. *Learning to Change the World* is also a story made possible by Nicholas Negroponte, the MIT researcher and

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cofounder of the MIT Media Lab, whose early visions for the XO laptop came to fruition despite ceaseless political, economic, and educational challenges. In addition to Papert and Negroponte, an assortment of other people make brief appearances in this book, including leading educational and technology thinkers and innovators, such as Alan Kaye, Cynthia Solomon, Marvin Minsky, Jean Piaget, Paulo Friere, John Dewey, and Robert Kozma. Of course, countless others have played vital roles in the project design, implementation, and evaluation.

Commendations and Criticisms

As Walter Bender and his colleagues point out, many thought leaders keenly anticipated this age of learner-centered learning in technology-rich environments. As shown in this book, technology in the hands of youth can be highly empowering. Nevertheless, this educational revolution did not come overnight. Instead, the authors reveal to us that it is incremental; successful revolutions come from evolutions.

Some of the prevailing criticism of the OLPC project has focused on the learning-related impact of the XO in schools. However, stepping back and taking a long view, you will likely see the need for local commitment for innovations. You will also discover many revelations not published by the press. What perhaps surprised me most in the book was the connection of OLPC to the rise of netbooks. While the authors fully acknowledge that they did not directly cause the netbook movement, they did, in fact, map out the means for others to build more power-efficient and smaller devices. As such, they played a crucial role in sparking the netbook movement.

What also amazed me as a former corporate controller and CPA was the extremely thin profit margins (i.e., $1 per XO) from which they managed to survive despite myriad roadblocks in government contracting, production cycles, and training. At the same time, it was refreshing to read a book about a project that has impacted millions of young lives, while still admitting that they have not come close to their original dreams and aspirations.

The authors should be commended for bringing up a series of debatable topics and issues related to the field of educational technology. For example, can product-driven social change spark paradigmatic change in schools and educational systems? As I digested their "Lessons and Reflections" section at the end of each chapter, I came to the conclusion that perhaps it can. In these ending reflections, there were numerous management and leadership principles carefully organized and explained (e.g., "The goal is not just to innovate, but also to create value"). Also worth reading and digesting carefully are the book appendices, which contain interesting stories and caveats related to major XO purchases and installments in different countries and regions of the world, including Peru, Nicaragua, and parts of the United States.

I also appreciated the frankness that I felt when reading different sections of the book. For instance, the authors fully admit to being arrogant at times. They acknowledge that the OLPC team set somewhat unrealistic expectations. As exemplified in a 2006 TED talk by Negroponte, there were quite lofty early targets established about price (i.e., $100), sales, manufacturing, and XO special features. Such bold projections attracted extensive media attention. However, in attempts to meet their audacious predictions as well as stay solvent, OLPC participants were often forced to wear the hats of fundraisers, marketing specialists, support personnel, computer designers, instructional designers, and teacher trainers.

Among my issues and criticisms are several noticeable typos in this book. These were distracting and led me to believe that the book was hastily produced. Second, there were issues that seemed to be rehashed several times, as if the four authors had ownership over different sections of the book but all of them wanted to tell the same story. Third, at times, I wanted to hear from the voices of Papert and Negroponte themselves. While the authors cited their work throughout the book and gave each full credit for their ideas, a book to fully capture and illuminate a project of this magnitude certainly warrants hearing, even briefly, from key OLPC leaders and founders in a few timely chapter quotes.

There was also an exciting admission in the book when the authors discussed the role of the instructor as one of guide who nudges or scaffolds students. It was here that I thought references to the work of Vygotsky and his contemporaries might be in order.

Finally, I was disappointed with their vision of the future detailed near the end of the book, as it seemed to simply mark where we have been and where we are today in terms of the XO laptop and similar products now in design (e.g., an XO tablet). No more bold predictions!

"Freedom to Learn" in Learning to Change

And what about the children for whom these XO machines were originally envisioned and built? The case studies in the appendices indicate that they explore ideas of personal interest, show up in school more often, and design computer programs, music scores, and even books. As Carl Rogers would say, they have freedom to learn and will be better able to self-direct their own learning later in life. While that is the target of the OLPC philosophy, at times I felt that children were not the real focus of this book. Instead, in many ways, the XO (i.e., the technology) was the centerpiece for Bender and his colleagues, as they describe their attempts to design, contract, build, and deliver it.

In the end, *Learning to Change the World* documents a project at the intersection of educational reform, learning theory, technology and business innovation, and personal creativity. As such, this book might be as important for technology mangers, heads of non-profit organizations, students in MBA programs, and government policy-makers as it is for teachers, instructional designers, or educational psychologists. Whatever your discipline, you will likely resonate with more than a few anecdotes and ideas in this book. And, as you read them, you can decide if, when combined, these have been world-changing or not. □

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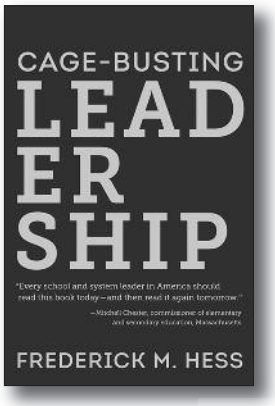

Assertive School Governance: Testimonials and Admonitions

Book Review: Frederick M. Hess. ***Cage-Busting Leadership.*** *Harvard Education Press; 296 pages; 2013; $29.95 (hardcover, $49.95).*

Reviewed by Steven Hackbarth

Endorsements and Inspirations

Crack open this tight volume to discover "fierce" endorsements by a dozen totally supportive high-level executives referring to the author of this book as "Rick." From among these, we glean that Dr. Hess portrays the status quo of schooling to be the major impediment to successful reform. The "cage busting leaders" he posits as models "combine noble visions with ferocious tactics" (p. ii) to combat obstructive regulations, laws, contracts, policies, certification, and "lousy teachers."

The author based this book on "the wisdom of those doing the work in the field," that is, "over a hundred school and system leaders, attorneys, reformers, and observers" (p. 261). He acknowledges 30 helpers, from whom "the good stuff was inevitably cribbed," while taking full responsibilities for "any mistakes, flaws, or inanities" (p. 262).

This powerful, informative, insightful treatise clearly was written with deep-rooted conviction and passion, reflecting a business/management perspective having wide appeal among a powerful segment of those vested in the *restructuring* of public schooling to *better implement their visions.* Dr. Hess credits his having spent "little time working in schools or school systems" (p. xiii) with avoiding that "natural insularity" that infects those immersed in K–12. His bio confirms just two years (1990–1992) service as a teacher in Louisiana, hardly enough time for acquiescence to so-called stifling school culture. Subsequently he earned a Ph.D. from Harvard, has published widely, has served on university faculties, is on the board of directors of the American Board for the Certification of Teaching Excellence, and is resident scholar and director of education policy studies at the American Enterprise Institute (AEI), a conservative-leaning "think tank."

The "Cages" of Public Education

The impediments to creative innovations, from Hess's perspective are: "District contracts and procurement processes, rules and regulations, state statutes and board policies…, making it harder to repair a fence, hire talented staff, or schedule grade-level team meetings" (p. 6). These "cages" or "mountains," as Hess portrays them, "mean that leaders are constantly sweating their way uphill, spending most of their time asking permission or battling to change old routines…, [which] leaves them little time or energy to tackle the things that matter most" (p. 223).

The bars of these "cages," according to Hess, are largely illusory or self-imposed. School administrators are either *ignorant of wide ranging exceptions and loopholes,* or are *too lazy to engage in the battles needed to get their way.* Hess criticizes the "educational leadership" establishment with being wrongly stuck in the five Cs—collaboration, consensus, capacity, coaching, and culture—to the neglect of the "mountain" of obstacles. Level the mountain, he says, and limited resources of talent, tools, time, and money can be better spent.

Writing with the authority of a board member of the National Association of Charter School Authorizers, Hess lauds charters as providing fertile ground for innovation. For Hess, the promise of charters lies primarily in the relative absence of "cages," especially "inherited policies or collective bargaining agreement[s]" (p. 36). And he firmly rejects the premise that chartering and accountability are simply ways to incrementally *improve instruction,* such as adding a new curriculum or reading program: "'Best practice' reform only addresses boulder-rolling techniques" (p. 237). Rather, it is the wider opportunities provided by charters for largely unfettered innovation that tends to foster sustained improvement (pp. 24, 36–37, 216; Hess, 2010).

Unions, Teachers, and Educrats, oh no!

A major theme for Hess is those troubling CBAs (collective bargaining agreements) that make it such a nuisance to terminate "lousy teachers." Thus, he cites many who have very cleverly managed mass terminations, either by closing schools or by reducing assessments of teacher performance largely to their students' test scores. This serves well to permit firing of burned-out veterans, to be replaced with less expensive, energetic, young, malleable teachers not yet vested in the "status quo." Never mind the vets having undergone extensive training, certification, and scrutiny over many years—if they are judged to be an obstacle, Hess provides a host of quick and easy angles to push them out, for example, "by creating an environment where the wrong people would choose to get off the bus" (p. 136).

Another grand theme is limiting the number of career educators involved in school decision-making to about 65% max, larger representations dooming committees to the morass of the stifling status quo. Fresh, 21st Century insights are rather to be garnered from business tycoons and *consigliere* attorneys. Hess expresses confidence in funding these new, pricey partners, without necessarily having to increase funding; "cage-busters" know well where to make the cuts. Mistakenly attributing bank-robber Willie Sutton's

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"that's where the money is," to John Dillinger, Hess unapologetically targets school staff (p. 142).

Conclusions

Frederick Hess's book is valuable for illustrating well how school leaders with great ideas may find ways of implementing them, either within existing constraints, or by circumventing them. It admonishes them to make the effort or take on the fight. Also, it removes from charter schools the burden of having to invent "silver bullets" to prove their value; less restrictive conditions are said to unleash creativity and permit reallocation of resources (but for better *or* worse?).

Hess provides a valuable service in drawing sharp attention to countless ways in which *all* schools may become more effective and efficient. Set clear goals, gather baseline data, muster resources, remove obstacles, and get results. He boldly has taken on self-proclaimed "reformers" and so-called experts in "educational leadership." His arguments are cogent and persuasive, not to be taken lightly, and his allies are extremely powerful. Public education and teacher unions are on the defensive, vilified in the media. Parents are clamoring to get their kids into alternative schools; lottery "losers" enter public schools with largely unfounded low expectations.

Nevertheless, while giving voice to those who have successfully implemented their visions, Hess underplays the rationales for existing policies and practices, and the potential negative consequences of unfettered "leaders" for vulnerable stakeholders, especially teachers and students. Those of us valuing governance by consensus and hard-won teacher benefits and protections cannot escape contending with the realities expressed so forcefully in this book.

Thus, from a veteran teacher's perspective, this is a *one-sided advocacy text that gives vent to the frustrations of those overseeing school systems.* It consists largely of testimonials from officials with impressive titles, essentially unabashed boasting. Utterly lacking are evidence of negative consequences and dissident voices, for example, on Twitter, education scholar @DianeRavitch, union leader @RWeingarten, and parent advocate @LeonieHaimson.

Among the quotes we find a few condescending: "any time we've said something to teachers five or ten times, we should've said it twenty times" (p. 182); misattributed: George Bernard Shaw's line credited to Robert Kennedy (p. 201); or repugnant: "the principal…put the union president's daughter into that teacher's [the one he wanted to remove] classroom" (p. 198).

And among the promised "inanities" we find: "One problem is a K–12 culture where the words *productivity* and *efficiency* are often regarded as heresy" (p. 141); "education is perhaps the only sector where introduction of the personal computer has yielded a *decline* in measured productivity" (p. 143); and "in most schools, learning pretty much stops during those days [when the teacher is absent]" (p. 152).

Yet Dr. Hess has done great service in illuminating the monumental challenges facing high-level administrators, and has provided ample means of addressing them. With the above noted endorsements, I concur that it is *essential* reading for school leaders. That is not to say that I share Hess's confidence in the wisdom of such leaders, nor that I approve without reservations of his bulldozing tactics and narrow view of teacher worth. But he expresses very well the *perspective of the powerful,* and pushes into action those who may have acquiesced to "things as they are," rather than aspiring to "things as they might better be." □

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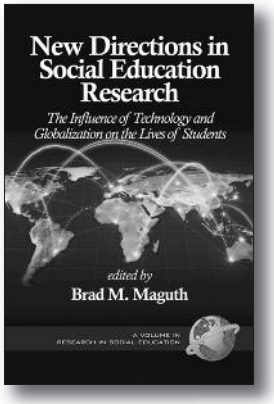

The Many Directions of Technology and Globalization

Book Review: Brad M. Maguth, Editor. ***New Directions in Social Education Research: The Influence of Technology and Globalization on the Lives of Students.*** *Information Age Publishing; 236 pages; 2012; $45.99 (hardcover, $85.99).*

Reviewed by Mimi Miyoung Lee

In this edited book, Brad Maguth emphasizes the critical need for schools and educators to better prepare our young learners for an increasingly global community. For Maguth, such preparation refers to "learning about and reading across cultural differences and geographic boundaries to confront the serious global ecological, economic, political, and social issues of our day" (p. 6). Listed below are some assumptions and key points that run through the book:

- Education is a social process.
- Social changes influence education.
- The advance of technology along with rapid globalization impact each other as well as the lives of students in a highly complex and important way.

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- Based on these social changes, new directions are needed for the future of social education.

Inside the Book

The significance of investigating the role of technology in global education is deftly captured in the introduction. The benefits of online discussion when dealing with difficult or controversial topics, examples of narrative-based online simulations (e.g., *Darfur Is Dying*), and the growing utilization of mobile technology for education are presented as ways to engage young people in global citizenship.

In Section I, the chapter authors present the current context of research about globalization, technology, and students. In Chapter 2, Baildon and Damico introduce *Relational Cosmopolitanism* for "inquiry-based social practice for understanding and addressing complex, multifaceted problems" (p. 27). They propose it as a guiding framework for salient social education curriculum issues, such as global climate change, militarization and terrorism, and the impact of multinational corporations. Gaudelli and Donaldson, in Chapter 3, argue for three generative dynamics that could provide a strong rationale for Global Citizenship Education (GCE) along with a case study on a Web-based initiative called Connecting Classrooms.

In Section II, Chapter 4, by Myers, examines "the potential of an international-themed online simulation to support the development of global citizenship" (p. 62) through the case study of ICONS (International Communication and Negotiation Simulation). In Chapter 5, Shin proposes using geospatial technology for global citizen education. Based on a spatial perspective, Shin's review and analysis of previous literature opens up new possibilities for developing a more place-based sense of identity and citizenship.

Chapters 6, 7, and 8 offer a close-up look at various projects where technology fosters collaboration in local and global contexts. For instance, Beal, Holcomb, and Lee's chapter on the Global Learning Initiative Project (GLIP) provides an intriguing example of a multinational, multimodal, project-based global learning initiative, where students from several countries collaborate on common global issues, such as health, environment, and the economy, through various interactive technologies.

Chapter 7, by Furdyk and Keith, documents the popular online global educational tool, Taking IT Global for Educators (TIGed). The authors show how TIG's sizable Online Community can engage youths in globally important online activities like the Sprout online course for social entrepreneurship and the Deforest ACTION program. As richly detailed in this chapter, TIG programs provide young learners opportunities to collectively work on the social issues and challenges informed by the global context.

In Chapter 8, Mathews proposes the use of Photovoice, a version of Community-Based Participatory Research (CBPR), while providing several emotionally impactful project examples.

Turning to Chapter 9, at the start of Section III, Gragert lends vital insight into the International Education and Resource Network (iEARN-USA) Program for in-service teachers and proposes new ideas for the professional development of teachers in global education through innovative uses of technology. In the final two chapters, Peters as well as Voithofer and Henry address important issues of empathy, bias, and discrimination in virtual worlds (e.g., cyberbullying).

Critique

The contributing authors unanimously argue that fostering critical global awareness and engagement skills in our students is an urgent issue. Thus, more inquiry-based collective modes of teaching and learning should be incorporated. The authors also show how various emerging technologies and social media can and will serve as crucial components in achieving that goal. Any reader who is involved in social education will be excited by the myriad ways of "Going Global" today; getting a sense of such global education pathways using various forms and types of learning technology is definitely the main strength of this book.

The pedagogical possibilities shown through the chapters are especially exciting as they present revolutionary ways to foster global citizenship through localized educational experiences.

However, for readers who are searching for more critical perspectives on the impact of using these simulations, games, and other online global resources, or perhaps are seeking findings of completed experimental research studies, this book might not fully meet expectations. While most chapters make connections to research to some extent, only a few of them provide findings from finished studies. The majority of the chapters focus mainly on the explanations of cases and models in their various phases of development and implementation.

In this sense, *New Directions in Social Education Research,* on the whole, feels less about the research itself and more about the innovative programs and projects that *could lead to important ideas for future research.* And, perhaps for this reason, the book begs for deeper discussions on the possible implications of using these games and global interaction tactics in the classroom.

For example, the aforementioned narrative simulation "game," *Darfur Is Dying,* has generated some important debates on its possible impact. While some welcome anything that may spark interest in the country (i.e., Sudan) and its issues as a clear gain for advocates, others criticize the gaming format as a possible oversimplification of the problem. How can the technology help move students beyond simple awareness and toward fostering more critical perspectives on the issues brought about by the very technology? Expanded discussions on such complex issues would have been a welcome addition to this volume.

Nevertheless, this book will serve as a useful resource to readers who are interested in the current status of global education and are looking for possible applications of technologies to promote collaboration among learners in multinational contexts. They will find many interesting ideas and frameworks that can guide and inspire both teachers and learners across age groups and disciplines in this globally interconnected world. □

Looking Ahead Looking Back

Denis Hlynka

New New and *Old Old:* Towards a Taxonomy of Educational Media

Two books recently crossed my desk that provide polar-opposite analyses of educational media. The first is titled *Academic Films for the Classroom: A History* (2010) by Geoff Alexander and published by McFarand & Co., while the other is *New New Media* (2009) by Paul Levinson and published by Penguin Academics

The use of the terms "new new" in Levinson's title is not a typo, but a useful designation. However, the complexity involved in defining these terms adequately can become overpowering as new layers overlap.

Classifying Educational Media

Based on Levinson's book, let us attempt a classification:

New media: "People can use, enjoy, and benefit from them on the user's rather than the medium's timetable, once the content has been posted online" (p. 3). In general, then, new media are those media in which the user must wait for the content to be produced by someone else. Examples include e-mail, Wikipedia, Websites, and online databases.

Old media (by extension of the above): These are media, as Levinson says, "by appointment." People need to wait for the delivery of a newspaper, or a weekly broadcast of a television series, or the purchase of a new book at the local bookstore (p. 3). Old media are typically one-way.

New new media: "…as opposed to the traditional 'new media' of e-mail and Websites, [these 'new new' media] allow and encourage all consumers to become producers, readers to become writers and publishers, and viewers to become performers." (From the online Website at *pearson highered.com* .)

Old old media: This is my term, not Levinson's, and will be discussed further in this column. For the moment, it is here only as a placeholder.

At this point we can place these in a more taxonomic order:

- *New new media*
- *New media*
- *Old media*
- *Old old media*

Discussion

Here is the catch: each category can dissolve into the other. Consider a blog. If you, as a consumer or a learner, can sit down, write, and post your own blog, then that blog is *new new.* On the other hand, if you read someone else's blog and comment in the "comment section," that is *new* media. But, if you merely read the blog for information, that is perhaps *old* media.

Here is how Levinson explains the terminology. He asks "Why 'new new' media rather than social media, or Web 2.0, or even 3.0?" His answer in part:

> Just plain new and old media had significant social components as well…ranging from group e-mails to online bulletin boards…Indeed what is a bookstore reading group if not a social medium?…The social aspect of new new media, though crucial, is not unique enough to warrant our use of the term's interchangeable nature.…Other primary elements of new new media—such as the consumer becoming a producer—can easily be practiced individually, not socially, as in writing a blog post.

So we now have *new* media and *new new* media, rather specifically defined. It is appropriate then to carry the argument to a discussion of *old* media, and why not *old old* media? *Old* media, following Levinson's lead, would be those media that are still used, that can probably be rather arbitrarily dated pre-1990, and tend to be one-way disseminators of information. (Perhaps the date should be pre-1980 or perhaps pre-1970, but the final choice is quite arbitrary.) *Old* media are what we sometimes refer to as "traditional media": film, radio, television. *Old* media still have a place in the educational system and are still used regardless of their age. The textbook is a classic example. Textbooks, indeed all books, are still very much in use in the second decade of the 21st century. While there are dire predictions of the end of the book, nevertheless, there can be no doubt whatsoever, that at least at this moment of writing, books exist, magazines exist, bookstores exist, and physical libraries exist.

Some libraries, however, are arbitrarily cutting out their print subscriptions and relying only on electronic journals. This is a serious mistake that will only serve to marginalize such libraries. Serious libraries, with any pretension to calling themselves libraries, will contain old media, books, and journals, as well as new media.

Old Media and *Old Old* Media

So what might be "old old" media? Obviously these are *media that fit into the old category, but are in fact*

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obsolete and no longer used. The 35mm filmstrip, once affectionately called a "headful in a handful," is now a dead medium. The 8mm film loop has likewise vanished, as has the 8rpm record. The long-play record is in a borderline position. Its supporters are vocal and vehement that the analog recording somehow captures "real sound" that is less artificial than its digital facelift.

For this reason, at least among connoisseurs and aficionados, LP records, at the moment, belong in the list of still-used and still-prized *old* media.

Educational film, the kind once shown in classrooms around the world, and once the ultimate standby exemplar of educational technology, has fallen into the category of *old old*. Its value is almost entirely archival.

True, these old films have not entirely vanished, and indeed are beginning to resurface on Websites, such as Internet Archive, or YouTube, or Turner Classic Movies. Some of these films transferred well to VHS and Beta format. Beta falls into the *old old* category, while VHS is just barely hanging on as *old* media.

To summarize: *New New* media by Levinson captures the potential of blogging, facebook, Wikipedia, twitter, and a growing list of the *new new*. In 13 chapters, Levinson identifies, categorizes, and summarizes.

Three caveats are necessary at this point. First, it is sometimes unclear whether these *new new* media are educational media for the purpose of teaching/learning, or whether they exist at the broader level of their generic impact on society, not merely in the classroom. There is a certain amount of slippage, which becomes potentially important. Arguably, social media for entertainment are not the same as social media for pedagogy.

A second caveat: There is a second kind of slippage or overlap between categories. Where do you place a blog? If it is user generated and interactive, then it falls into the *new new* category. If it is merely read for content but not interacted with, then it is *new* media. If it becomes "old hat," and some argue that it already has, then it falls into the old media category. In short, it is not enough to name the technology but to examine its use, in order to decide where it falls along the continuum.

A third caveat continues the slippage. Literary critic David Thorburn, among others, argues that early modern 20th Century literature, the literature of James Joyce, Ford Maddox Ford, and Virginia Woolf, to name only three authors, cannot be read the way we typically watch television, merely as "couch potatoes." Instead, Thorburn argues, the reader must "collaborate" with the author in order to make sense of the pastiche, episodic, aggressively complex, post-impressionistic style of these writers. The central concept of the "unreliable narrator" makes no sense without careful reader attention and participation in the work, a task far more demanding than mere reading. A work like *Finnegan's Wake*, Thorburn would argue, not only fails as a work of *old* media, but must transcend *new* media and become an exemplar of *new new* media *par excellence*!

Classroom Films

The other book, which might even be a companion book to Levinson's (depending on how one's synapses snap), is called *Academic Films for the Classroom: A History.* It is important to be placed here because it focuses clearly on the *old* and *old old* side of the continuum. It tells the rest of the story.

Academic film is a wonderful, sometimes nostalgic, but more importantly archival and archeological construct, involving searching, finding, and/or re-presenting content for the classroom in the form of *film* as it grew from the 1920s into the 1980s. If there is a weakness in Alexander's study, it may be that it focuses mainly on titles and producers, rather than theories of the mass media and theories of mass educational media. There is no discussion of Edgar Dale's Cone of Experience, or the theory behind educational training films of World War II. On the other hand, the Educational Film Library Association (EFLA) gets a solid chunk of discussion here, as does the almost forgotten but extremely significant film titled *Project Discovery,* the first systematic attempt to explore media integration on a widespread bases. *Anyone who wishes to study the integration and infusion of new technologies into the classroom needs to start by viewing this 1960 film (available online).*

Academic Films for the Classroom suggests that there were some 100,000 16mm films used in North American classrooms from the 1920s till the 1980s. This book documents that history.

The two books together provide a significant field of study for researchers. Contemporary researchers have become too complacent, living not only in a computer based "cloud," but in a "head-in the clouds" environment. Alexander's book shows that we have always been asking these questions, and the first thing that contemporary researchers need to do is to acquaint themselves with what has already been done.

An aside is necessary in terms of Alexander's book. The National Film Board of Canada, which gets substantial treatment, has recently placed its entire film library online at *www.nfb.ca* . Many of these films-cum-digital are surprisingly viable even today.

Expanding the Horizon

What these two books have done is to expand the horizon of educational media studies in two directions. Once all media were either new or old. But taking a lead from these two books, the world of educational technology has expanded forward into *new new* and then collapsed backwards into *old old*.

If there is a difference between the digital immigrant and the digital native (neither of the two books mention this dichotomy), it is this: A digital native is born into a cloud of "new new" media and sees only the wonders of the future. There is no stepladder back to the past, or down to firmer ground; and, if there is, all the rungs have been carefully removed. Yet this digital native is familiar and comfortable within the world of the *new new*.

The digital immigrant, on the other hand, stumbles with confusion and uncertainty at the promise of the *new new*, but at the same time comes with experience, and with a past that has actually seen the rise and fall of the classic educational film. Our time is filled with both immigrants and natives, digital or not. One is not better than the other. Both contribute to the fabric of who we are. Levinson shows us the way up; Alexander shows us the way back. We need both. □

Educational Technology Points of Inflection

Michael D. Bush

Individualization in Learning: A Key Point of Inflection

Introduction: Many Choices for Consumers, Very Few for Our Students

A stay on the campus of Notre Dame University can be an exhilarating experience for students there or even for visitors who come for a short stay. Whether attending classes, contemplating the "Touchdown Jesus" mural from the seats of the famous football stadium, studying in the Hesburgh Library on which the mural is located, or attending a conference, as I did last summer, the lessons learned can be many and varied.

The particular insight I gained there came during the annual symposium of the Computer Assisted Language Instruction Consortium (CALICO). Rather than resulting from listening to a presentation in a lecture hall or reading in the library, however, my insight came after a delightful bike ride along the St. Joseph River in South Bend, Indiana.

At the end of my ride and just before returning to the dorm, I stopped for dinner at Five Guys Burgers & Fries in the Eddy Street Commons, just off the south side of the campus. My insight was not new. Rather, it was a renewal of a sense I had gained in my readings over 40 years ago, beginning first with Alvin Toffler's *Future Shock* as an undergraduate and continuing with other works in graduate school (George Leonard's *Education and Ecstasy*, Toffler's *Third Wave*) as well as for several years afterwards through other varied works and comments from writers like architect R. Buckminster Fuller and science fiction icon Isaac Asimov. They all asserted that our educational system was created to solve the problems of ages past.

Standing in front of Coca-Cola's newfangled FreeStyle drink machine at Five Guys, it dawned on me that individualization had reached a level not even imagined by the writers who had inspired me. Quoting McLuhan, Toffler wrote, "When automated electronic production reaches full potential, it will be just about as cheap to turn out a million differing objects as a million exact duplicates" (Toffler, 1970, p. 238).

I stood there for a moment, contemplating the choices before me, "Should it be Sprite with cherry, Barq's Root Beer with vanilla, or perhaps strawberry Minute Maid Lemonade?" I can't remember which I chose. Indeed, it might well have something far less exotic than the choices available. In fact, it could have been Coke with cherry, which is actually available on the typical supermarket shelf from 12-ounce cans to 2-liter bottles, all labeled, "Cherry Coke," itself a function of the market demassification predicted by Toffler. All we had when I was a kid was Seven-Up, Coke, and Pepsi. Oh, let's not forget that Southern favorite, Royal Crown Cola, usually referred to as RC Cola, or that Texas favorite, Dr. Pepper.

As the multi-flavored, carbonated concoction flowed into my cup, a sense of *déjà-vu* invaded my consciousness. There I was, in attendance at a conference with many sessions discussing the benefits of technology in education, and here I was about to partake of individualization that even surpassed what McLuhan had predicted. The product did not even exist at the time of purchase and was actually being "manufactured" as the machine delivered the liquids to my cup.

Coca-Cola's Website heralds their new innovation: "Not since the days of the friendly neighborhood soda jerk have so many people fallen in love with a beverage dispenser." Despite the market-speak, the message is a clear one: A consumer can now walk into any one of thousands of locations and choose from 100+ combinations of flavors. The machines are not only synched with Twitter (@ccfreestyle) but also consumers can provide Facebook with location information and see a map of stores where the machines are located.

Returning to what has become the first of several encounters with FreeStyle, I watched my cup fill with whatever individualized blend of flavors I had selected and thought of my grandkids, several of them having just finished their school year. What sort of choices have they had in their schooling? How many "flavors of education" were actually available in each of their classrooms? The lesson is clear: The tastes of purchasers of soft drinks are now much better met than the individual needs of students in our schools today.

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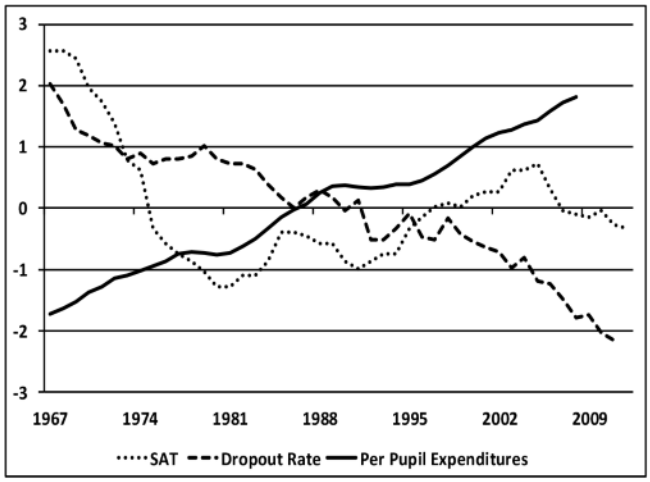

Figure 1. SAT scores, school dropout rates, and per pupil expenditures displayed on a standardized scale.

So Saith the Soothsayer…

With respect to consumer tastes, the predictions by McLuhan and Toffler were spot on, but for education? Not so much! After stating that education had been organized for the "mass production of basically standardized educational packages" (1970 p. 271) Toffler wrote, "One basic complaint of the student is that he is not treated as an individual, that he is served up an undifferentiated gruel, rather than a personalized product" (p. 271). He then predicted:

> Long before the year 2000, the entire antiquated structure of degrees, majors, and credits will be a shambles. No two students will move along exactly the same educational track. For the students now pressuring higher education to destandardize, to move toward super-industrial diversity, will win their battle (p. 271).

So what has happened since Toffler's optimistic educational prognostication? Can we say today that the needs of the individual are being met and that the old system is in shambles? The shambles part essentially connects with the report by President Reagan's National Commission on Excellence in Education, *A Nation at Risk* (1983), which described the country's educational system: "If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war" (p. 5).

To go beyond the negative and mostly subjective assessments that have echoed those sentiments, I created ***Figure 1*** with SAT data from the College Board (2012) along with pertinent information from the National Center for Education Statistics (Snyder & Dillow, 2012). To facilitate comparison on a single chart of the disparate variables, I standardized the three variables over the time period from 1967 to 2008, 2011, or 2012.

Despite significant increases in spending, the learning outcome of our students as measured by SATs has clearly not kept pace. To be a bit more specific, average education expenditures per pupil rose from $3,903 in 1967 to $10,694 in 2008, stated in 2008–2009 dollars. Even more startling is the fact that the average expenditure per pupil had already increased almost nine times by 1967, from $454 in 1919, with a total increase of over 24 times from 1919 to 2008!

On the more positive side, based on the data from which the graphic was created, the number of pupils per teacher in the public schools declined from 22.3 in 1970 to 15.4 in 2009, while the number of dropouts decreased from 17% in 1967 to 7.1% in 2011.The assumption that the decreased dropout rate is the result of this improvement in the pupil to teacher ratio is an easy one to make: An improved student to teacher ratio will create the opportunity for increased attention to the individual needs of students, which could well reduce the number of students who drop out of school.

It is worth noting, however, that the escalating per pupil expenditures as seen in ***Figure 1*** demonstrate how expensive it is to reduce this ratio. This raises the distinct possibility that increasing these expenditures could crowd out initiatives to add technological enhancements that are better suited to learner-centered education than simply adding more teachers. Indeed, this type of change might well improve learning outcomes in a way not reflected in the SAT results in ***Figure 1***, which clearly shows that these scores have not at all followed substantial increases in spending.

As positive as these numbers might appear, there is more to the story. The College Board announced last fall that only 43% of college-bound seniors are college-ready. College Board president Gaston Caperton said that "Our nation's future depends on the strength of our education system. When less than half of kids who want to go to college are prepared to do so, that system is failing" (College Board, 2012b). Next, the City College of New York announced that 80% of their students come to them unable to read at the college level and "need to re-learn basic skills" (CBS New York, 2013). Creativity expert Sir Ken Robinson (2006) believes the problem is worse than that, maintaining that schools needlessly sacrifice the creativity of children everywhere:

> We stigmatize mistakes. And we're now running national education systems where mistakes are the worst thing you can make. And the result is that we are educating people out of their creative capacities.

Conclusion

Many people recognize that education must change. Call it education reform, school transformation, or whatever, but the suggested changes must include attention to individual needs akin to how the FreeStyle machine responded to my tastes for a dinner beverage. Bluntly stated, the instruction provided in any classroom probably only addresses the individual needs of one-third of the students. One-third of the students are either bored to varying degrees simply because they are not being challenged, and a significant portion of the remaining third are at any given moment unsure of what the teacher is talking about.

Some experts propose to address the problem with

"personalization," others with "differentiation," and still others with "individualization," once again demonstrating the profession's affinity for "buzzwords" that seem to say the same thing and need to be explained by those same experts. To do that without also providing an implementable solution that surpasses the status quo is nothing short of depressing.

Yet, writers like Toffler, Asimov, and Fuller among others say change is necessary simply because schools today are not up to the challenge of the Information Age. The schools date from a time when collective protection for children was needed on the American frontier or when former farmers needed to learn to do boring, repetitive tasks in the expanding factories of the Industrial Revolution.

Harsh assessments aside, we absolutely must move beyond a system geared to students who "succeed" without individual attention, to whom too often we teach canned answers to questions. The objective should be to help all students hold on to their creativity, not fear failure, and be wise enough to determine which questions should in fact be answered. Schools must also provide the tools necessary for that endeavor. The resulting success at addressing individual needs in the learning process will constitute a ***point of inflection*** on the development curve of educational technology.

We will next discuss the role that educational technology can play in increasing the role of individualization in education and the design principles that will facilitate system development and implementation toward that end. □

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New Issues, New Answers

Marc Prensky

Want the Best Network? Use the Students to Build It!

We are completely ignoring our best technology resource: Our kids could give us the best technology network in the world—if we would enable them!

A Powerful Resource

Anyone who has had any real contact with kids these days (i.e., outside of our rigid schools with their testing-oriented classrooms) knows how excited, smart, and capable today's young people can be—especially around technology, and particularly when properly challenged.

Our school-age kids are, in fact, our very best resource for getting many things we need done—it's hard to beat the combination of capable, low-cost, and enthusiastic!

So how could we channel and make use of this powerful resource?

A New Perspective

If we change our perspective about kids for a moment—from that of students competing individually with each other for grades (and for places in college and in life) to one of a powerful cohort working together to accomplish goals useful to all—answers begin popping out at us.

Perhaps the easiest and most useful challenge we could give this cohort would be to make the U.S.'s (or whatever country does this) technology network for education the very best in the world.

How could students do that? Doesn't a great technology network require professionals? Big companies? Big investments? ADULTS, in short?

I don't think so. The adults and the technology companies would need to be involved, of course, but they don't have to be the drivers, or even the doers. The kids can be.

Marc Prensky, *a Contributing Editor, is author of the 2001 article "Digital Natives, Digital Immigrants" and is an internationally known speaker, writer, consultant, and game designer in education and learning. He is the author of five books and is the founder and CEO of Games2Train, a game-based learning company with clients in business, government, and education. Marc holds an MBA from Harvard and a Master's in Teaching from Yale. Many of his writings can be found at* ***www.marcprensky.com/writing*** *.*

I'd propose we start with our schools, move to our neighborhoods, and eventually connect all of us.

What Do We Need?

Suppose, for example, we want to powerfully bring the most powerful network possible into a school. How does it get there? Cable? Kids can lay it from the nearest point, and learn how to splice it. Satellite? Kids can build a dish. The cable and phone companies could help here (all have philanthropic arms).

Then we need routers. Kids can build these, or adopt existing ones. Cisco would be the great partner here.

Wi-fi in every classroom? Kids can build wi-fi amplifiers—using tin cans!

This is not even a stretch. The instructions for doing all these things are already on YouTube (Fiber Optic Mechanical Splice: *http://www.youtube.com/watch?v=haey8XdILf0* . Building a satellite dish: *http://www.youtube.com/watch?v=YgLfP_S3iQE* . Wi-fi repeaters with tin cans: *http://bit.ly/gSnMJh* .

What's left? Getting the highest bandwidth signal. (All our schools already get at least low bandwidth.) This signal is, of course, already available from many carriers—they just charge more for it.

So either we get students to lobby the carriers to subsidize it and provide it cheaply to schools (e.g., at the same price the schools are paying for the current, inferior bandwidth) and/or we get government, or a company, or a philanthropy like Google's or Gates's to foot the bill.

And it's all fantastic learning.

Additionally, points out consultant Mark Anderson, many schools already own airwaves (spectrum), which can be used or traded here.

Once the schools are done, the next step would be to extend the fast network to the neighborhoods where the kids live. Bringing access to the community is also not that hard—it's already been done in several places (like low-income Lemon Grove, CA, whose network, built with federal and other grants, is used as backup by the local police and fire departments).

Google is currently making free wi-fi available in the multi-block area around its offices in New York City (and, I assume, lots of other places). Why not enlist nearby school kids (with company/school guidance) in exchange for learning something useful? Google already brings groups of school kids to its offices frequently. How about teaching them these skills while they're there?

Self-Organizing Tech Corps

Could our students self-organize in this way? Could they start and run a school-based, district-based, state-based, and national-based "tech corps"?

Yes they could. In fact, it *shouldn't* be done "top-down"—like Scouts or 4H—although some of those organizations' knowledge may be useful. There are already good examples of large groups of young people self-organizing—from street groups to video game guilds. Could we turn our kids' organization skills to the "useful side"? I bet we could.

Picture a tech corps in each school, self-organized by kids, based on merit alone, with a non-voting volunteer faculty sponsor to keep an eye on them. Kids would make the rules, set the priorities, figure out how to get things done.

Their "prime directive," and only goal, would be this simple one: "Make your school's network equal to the best in the world." We'd encourage them to meet with and try to enlist the aid of whomever they can in business and government.

Our main role as adults would be to make sure they don't hurt themselves, get into trouble, or do anything illegal.

Our other job will be to pick up our jaws when they drop at what the kids are capable of accomplishing when unleashed.

Each school would be trying to be the best—not in competition for prizes, but in a common effort towards a collective goal. The school teams would also be meeting district- state-, and country-wide—mostly virtually, perhaps sometimes in person—to coordinate, set standards, and share good ideas.

Future student tech corps members would maintain and upgrade the system, keeping it the best as technology advances. Does anybody think that the money (and the necessary volunteer supervision) could not be found for this?

In fact, why not make the whole challenge worldwide, with a dedicated, kid-created YouTube channel and other tools supporting the effort in multiple languages, and promoting worldwide, student-created, networking paradigms?

Let's Go!

So let's summarize:

I'm proposing a continually ongoing project (first building the networks and then keeping them running and current as technology improves) that involves useful and important learning, that kids could point to as their own and be proud of, that everyone would benefit from, and that would require little additional work from overworked adults. This would also be a laboratory and paradigm for other good uses of student resources. Sound good?

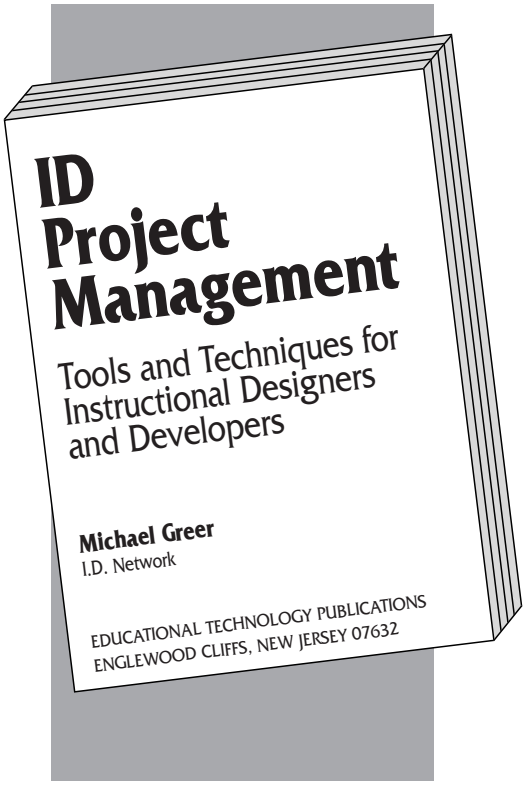
What problems and issues could we foresee?

Quality? The kids can work with experts to set and enforce their own quality standards. Safety? We can supervise. Security? We can put the top kids in charge of ensuring this. Taking adults' jobs? Hardly, given the project's limited scope (i.e., schools, educational use). Intellectual property theft? None involved. Adults' time and physical resources? That's what philanthropic arms and foundations are there to support. Plus today's kids are great at recycling and reusing stuff. Internal Politics? I bet these kids could show us all a thing or two about getting things done.

Once our networks are the best and our kids have some experience under their belts in working together, the young people could move on to other badly needed projects about which they are passionate—things like health, environment, sanitation, and literacy spring immediately to mind.

All this requires, really, is saying to the kids: "Go." Who might be against it?

Your comments are welcome at ***marcprensky@gmail.com*** . □



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