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# Education 3.0: breaking the mold with technology

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# Education 3.0: breaking the mold with technology

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In order to meet the needs of today's knowledge economy, education needs to move beyond the industrial age approach of treating all learners as if they are the same and adopt a learner-centered model of education suitable for the information age. To support this model, a new and transformative technology is needed that focuses on mastery and customized learning. This article reviews the existing approaches to educational technology before proposing a new, customizable, open, and interoperable technology: a personalized integrated educational system (PIES) that provides full functionality for students, teachers, parents and other stakeholders and bridges the gaps between formal and informal learning. PIES' four primary functions: record keeping, planning, instruction, and assessment, as well as secondary functions, are defined and described. Future challenges and research opportunities are also identified.

**Keywords:** learning management system; personal learning environment; educational technology; educational software; educational change



Dissatisfaction with the current paradigm of education has become increasingly public and contentious with blame being variously assigned to teachers and their unions, governments and their policies, funding, parents, and students. Ultimately, the current educational system was designed to meet different needs and goals than we currently face in the information age. Just as society has seen three major paradigms (Toffler, 1984), it is past time that a third paradigm of education be created to meet the needs of our information age.

The first paradigm of education in the agrarian age utilized the one room schoolhouse paradigm to meet the needs of society. The second paradigm of education in the industrial age invented the factory model paradigm of education, where students have been expected to master the same material in the given amount time, or else they acquire learning deficiencies (Reigeluth, 1994). The information age society that we live in today calls for a new educational system and paradigm, where students reach mastery through customized, personalized learning plans, and technology will necessarily be a critical element.

This article describes the recent history of dominant educational software such as course management systems (CMSs) and learning management systems (LMSs), examines current trends such as the push for open educational resources (OERs), learning object (LO) repositories, and personal learning environments (PLEs), and identifies the promises and

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challenges with each. We instead argue for the need for a new approach, a personalized-integrated educational system (PIES), which goes beyond previously advanced solutions to fully meet the needs of an educational system suitable for a post-industrial society.

## A recent history of dominant learning technologies: CMS and LMS

Two dominant technologies currently in use in education are the CMS or virtual learning environment (VLE) and the LMS. The term LMS is often used interchangeably with CMS and VLE, which are used in many universities to push course-based content to students, facilitate course-based communication, and manage online courses.

### *K-12 learning management systems*

LMS has been used to describe a variety of educational software, but at its core, it is a software that manages the entire learning process rather than just delivering content or being limited to individual courses (Szabo & Flesher, 2002; Watson & Watson, 2007). Examples of a K-12 LMS include Edmentum (formerly PLATO), Pearson digital learning, and SchoolNet. LMS is also used to describe software that companies use to track and manage training for employees (Martindale & Dowdy, 2009). A review of K-12 LMSs showed that K-12 LMSs often rely largely on drill-and-practice instruction, do not integrate well with outside software, and offer limited customization options for teachers (Watson, Lee, & Reigeluth, 2007). There is yet to be a single platform that offers all of the necessary features for supporting the sort of truly learner-centered and customizable educational system we envision as necessary for the information age. Our study of the utilization of PLATO in a disadvantaged alternative school found that implementation of the software, lack of professional development for teachers on the use of the software, and a focus on using the software largely for remediation were additional challenges to effective use of an LMS (Watson & Watson, 2011). Furthermore, the software brings with it significant costs for schools purchasing it and often additional training and support costs as well.

### *Course management systems*

In higher education as well as in some K-12 schools, CMSs have become nearly ubiquitous. CMSs (also often identified as LMSs and VLEs but hereafter identified only as CMSs) are focused on the management of individual courses, in contrast to the comprehensive K-12 LMSs. Examples of CMS include Blackboard, WebCT (now owned by Blackboard), Sakai, Angel, and Moodle. Typically, the instructor manages a course, whether online, face-to-face, or blended, by uploading and presenting course content (Web pages, presentations, readings, etc.), reviewing the roster of students, making assignments and grades available, and communicating with students via email, announcements, or discussion board posts, all within the CMS.

CMSs, despite their widespread use, have seen increased criticism, particularly from advocates of PLEs, which are discussed in the next section. The course-oriented nature of a CMS automatically entails certain divisions within the learning process and seeks to replicate the teacher-centered paradigm of the traditional classroom (Attwell, 2007a; Bush & Mott, 2009; Weller, 2009). As we look toward a mastery-oriented, learner-centered approach to learning as opposed to a teacher-led approach, the artificial restrictions that result from grouping students into classes and imposing divisions between academic subjects become significant challenges and obstacles to learning. Furthermore, the CMS places

full management control under the auspices of the instructor, focusing on institutional control (Attwell, 2007a), so students have little control over their learning environment, another characteristic that fits the current teacher-led educational system but is not suitable for an information age appropriate system. CMSs have often been used largely as static repositories to store course syllabi, assignment descriptions, and lecture slides. While some CMSs support more advanced features such as discussion boards, wikis, blogs, and chat rooms, few instructors use these, and the complex CMS environments can be inefficient and difficult for the average teacher.

CMSs are also proprietary systems, stored on school servers, closed and restricted from interaction with resources outside of the school and CMS. As we describe in the following section, advocates of PLEs call for a move away from this institution-oriented approach to educational software and instead call for learning environments that support customization, interoperability, and learner control.



## The push for openness, customization, and interoperablity: LOs, OERs, and PLEs

In recent years, there have been increased calls for decentralized learning technologies which better support customization and the incorporation of numerous, open, and discrete tools. Bush and Mott (2009) define open technology as "tools, processes, and frameworks that interoperate in an open fashion to create and deliver content that is itself accessible, flexible, and repurposable" (p. 3) and argue that it "is a critical enabling factor in the transformation and improvement of learning" (p. 4).

While openness can be taken so far as to mean free to the user, such as in OER, or to mean providing full access to view and modify the source code, as in open source programming, the key focus is on customization, modularity, and interoperability (Bush & Mott, 2009). This movement is largely reflected in three primary technologies: LOs, OERs, and PLEs.

### *Learning objects*

LOs are a technology based on the concept of object-oriented programming. LOs are instructional components that are reusable and scalable. By having a repository of LOs, an instructor could locate and use LOs that fit her instructional objectives for her students and then apply it to her specific context. By sharing LOs, instructors would not have to waste effort reinventing the wheel for each lesson, but instead locate and use available instructional components that have already been developed. A number of LO repositories exist, such as the Merlot project, and some online educational communities, such as TeacherTube, could be considered LO repositories. However, despite years of calls for such repositories, problems have arisen to prevent the widespread use of LOs that was envisioned.

One problem has been the issue of how to find and share suitable LOs. Standards such as Sharable Content Object Reference Model (SCORM) have been and continue to be developed to make this task easier and still retain firm proponents of their potential impact (Bush & Mott, 2009; Fletcher, Tobias, & Wisher, 2007); however, development of instruction, particularly e-learning instruction, can be expensive, and applying standards to develop LOs increases the time and money required for this development, as developers are often responsible for understanding and applying the standards themselves on top of their development work. Furthermore, there is the issue of competing standards, the lack of adherence to standards by some developers, as well as the issue of the quality of the LOs themselves.

Additionally, if an LO is to be made discrete enough to be reusable in multiple contexts, it may become overly simplified and not as effective, as opposed to a well-developed LO, which may be too complicated or context-specific to be useful for more than its originally intended context, a challenge leading some to question whether the concept of LOs is dead as a useful approach to sharing instruction (Wiley, 2006). Developers are faced with either trying to develop a one-size fits all approach for their objects, or choose to develop for a specific context which may be too narrow for adaptation to a variety of contexts.

Finally, as previously described in the K-12 LMS discussion, some software companies already have spent enormous resources to create repositories of LOs that they have developed over decades. However, these companies have invested to create these objects and therefore are unwilling to make them available to anyone who is not a paying subscriber. Furthermore, as also mentioned in the LMS section, these LOs often lack the ability to be customized and are drill-and-practice-oriented.

However, LOs represent an important shift on a number of levels from traditional approaches to instruction. They focus on the concept of scalability, and open, sharable, and adaptable content and could play an important role in the realization of a more learner-centered paradigm.



### *Open educational resources*

In 2001, the Massachusetts Institute of Technology (MIT) began its Open Course Ware (OCW) initiative, in which it began making its course content available for free over the Internet. That has now resulted in open access to undergraduate and graduate course materials and modules covering nearly the entire MIT curriculum, currently approximately 1900 courses. In 2002, UNESCO held a forum on open courseware for higher education in developing countries and coined the term OER, defining it as:

> "technology-enabled, open provision of educational resources for consultation, use and adaptation by a community of users for non-commercial purposes". They are typically made freely available over the Web or the Internet. Their principal use is by teachers and educational institutions [to] support course development, but they can also be used directly by students. Open Educational Resources include learning objects such as lecture material, references and readings, simulations, experiments and demonstrations, as well as syllabi, curricula and teachers' guides. (UNESCO, 2002)

While UNESCO's definition points to teachers as the primary target users of OER, Wiley (2007) notes that in reality the users of the OER projects at over 200 universities around the world are overwhelmingly learners. MIT's OCW site confirms this, stating that 85% of its users are either students or self learners, while only 9% are educators (MIT, 2010b). Ultimately, OER epitomizes the concept of openness and the use of technology to promote it by embracing the idea that "the world's knowledge is a public good" (Smith & Casserly, 2006, p. 10).

Despite the global spread of OER initiatives and users, significant challenges exist to both these initiatives and their users. Foremost amongst these challenges is the cost associated with developing and disseminating the materials. MIT's OCW reports a cost of $10,000 to $15,000 per course shared (MIT, 2010a). Smith and Casserly (2006) also describe the challenges of dealing with intellectual property rights as well as faculty are concerned about "freely sharing their intellectual capital and permitting the re-use of their ideas" (p. 12).

Like LOs, additional challenges include the difficulty of users locating desired resources. While OER has in some instances moved away from OCW's restrictive course-oriented structure, issues of flexibility with the use of resource materials continue to be a problem. In addition, since multiple initiatives exist at multiple universities across the world, implementation approaches and quality can vary. Finally, while the concept of OER in K-12 environments is powerful, to date, the OER movement has focused mainly on higher education, thus limiting its utility for K-12.

### *Personal learning environments*

PLE is a concept that largely emerged in response to the institution-focused nature of CMSs. Observing students utilizing Web 2.0 tools such as Facebook, MySpace, Wordpress, and MediaWiki, researchers noted the resistance many students expressed toward CMSs. While Web 2.0 technologies focus on social networking, personalization, and user-created and controlled content, CMSs are very much teacher and organization-centered. CMS and VLE organize materials based around the course, and student work does not have a life beyond that course (Mott & Wiley 2009; Wilson et al., 2006).

A PLE does not seek to contain all itself but instead connects to many services: (a) it does not restrain but gives users control in consuming, publishing, and organizing resources as well as adopting tools; (b) it does not provide one homogenized context but instead gives the user control in defining and customizing her own context; (c) it does not constrain interaction solely with educational tools, but instead needs to interact with systems offering their own application programming interface (API) or other Web services (applications such as Google maps do not make available their source code, but instead make available APIs which allow developers to understand how to connect to and use their service); (d) it does not protect resources, but instead shares them, supporting sharing, editing, and republishing; and (e) it does not operate within an organizational scope, but instead focuses on the individual while also connecting at a global level to available services and resources (Wilson et al., 2006).

PLEs push for utilizing Web 2.0 technologies to achieve learner control of the learning environment (Attwell, 2007b) and strive to support informal, lifelong learning with strong learner control. PLE advocates fall into those calling for client software, those looking at Web-based server software, and those wanting to utilize the existing Web 2.0 tools (Sclater, 2008). While a consensus definition does not exist, the core concepts clearly focus on learner control and a contrast to the institution-centric and closed nature of CMSs.

Potential challenges include how PLEs will interface with the existing LMSs, how users will be forced to adapt to multiple and changing user interfaces given the fast-changing nature of Web 2.0 tools, how users will manage the vastness of resources available on the Web, and how users will be forced to evaluate the quality of resources and information (Martindale & Dowdy, 2009). Of particular interest here is the challenge of how PLEs will integrate with the existing educational software because, while a personalized and learner-centered focus on educational software is an important shift away from traditional CMSs, using PLEs alone may result in overlooking the importance of other stakeholders in a learner's learning process. Furthermore, while the concept for PLE is very strong in its support for informal learning and learner control, its focus is not on supporting formal education, an issue being addressed by those calling for the integration or parallel usage of PLE with CMS. Wilson (2008) discusses the integration of PLEs into VLEs (CMSs) and notes that an institutional-developed PLE might be problematic and in contrast with the very goals of PLEs. Mott (2010) highlights the limitations of both LMS (CMS) and PLEs, and

recommends a mash-up he calls an Open Learning Network. We believe that while blending the best of PLE and CMS is a significant step in the right direction, it would still be insufficient for supporting a truly learner-centered paradigm, particularly in the K-12 context where additional stakeholders play significant roles in the learning process.

## PIES: a vision for transformative technology

In this section, we propose a conceptual framework for a new educational software format that is designed to systemically support the entire learner-centered learning process, including facilitating the activities of all stakeholders. Technology designed for an information age educational system would focus on mastery learning and customized learning. It would support learner-centered approaches where each student is able to work at her appropriate level and pace based on her actual existing skills and knowledge as opposed to being grouped by age. It would seek to merge appropriate aspects of the LMS and CMS, a consistent user interface, support across the entire learning process, and reporting and tracking features for teachers with the learner-control, open, and interoperable nature of PLEs, LOs, and OERs. Such a system does not yet exist, so no existing label is appropriate. Hence, we propose a new term, PIES. Ideally, a suitable PIES would be open-source software, similar to Moodle, allowing institutions and individuals to customize and modify the software for their own needs, and allowing it to be free or available at a reasonable cost. It would serve as the central template for stakeholders to customize their own environment by incorporating web apps to support their different needs.

The existing Web 2.0 sites, such as iGoogle, and the social networking sites Ning.com and Elgg.org, support easy customization for users, allowing them to modify a template with web apps from outside developers. Users can customize the look and function of their sites, controlling the flow of information into the site with really simple syndication (RSS) feeds and email, easily incorporating such features as blogs, discussion boards, and chats. This customization for ease of use is essential for the success of PIES or any new educational technology, as teachers, parents, and all stakeholders will be unlikely to use software that requires significant effort to learn.

PIES would offer advantages over existing software and over the current vision for PLEs. As previously discussed, the PLE puts a strong focus on informal learning and lifelong learning. As described in the vision for an information-age educational system, learners would have a great deal of choice in how they learn; however, teachers will still be very much needed in the role of facilitators and mentors of the learning process as learners recognize how to best manage their metacognitive processes. PLE focuses on informal learning; however, novice learners may struggle without formal support and teachers will still play a vital role in guiding students in planning and effectively managing their learning process. PIES will take the learner-centered concepts of PLE and provide additional supports for other stakeholders, such as teachers, parents, and community members who may play a role in student projects. PIES will utilize the social networking functions of Web 2.0 and PLE, while also storing private information, such as learner health records, learning style inventories, and other sensitive information that the schools will need to best serve the students but that should not be available to all users.

PIES will be systemic in nature in that it will support the management of the entire learning process while still addressing the need for personalized learning. So just as a CMS could be seen as a component within a systemic LMS application, a PLE could be

Table 1. PIES primary functions.

| | |
|---|---|
| 1. Record keeping for student learning | 1.1 Standards inventory |
| | 1.2 Personal attainments inventory |
| | 1.3 Personal characteristics inventory |
| 2. Planning for student learning | 2.1 Long-term goals |
| | 2.2 Current options |
| | 2.3 Short-term goals |
| | 2.4 Projects |
| | 2.5 Teams |
| | 2.6 Roles |
| | 2.7 Contracts |
| 3. Instruction for student learning | 3.1 Project initiation |
| | 3.2 Instruction |
| | 3.3 Project support |
| | 3.4 Instructional development |
| 4. Assessment for (and of) student learning | 4.1 Presenting authentic tasks |
| | 4.2 Evaluating student performances |
| | 4.3 Providing immediate feedback |
| | 4.4 Certification |
| | 4.5 Developing student assessments |



seen as a personalized learning component within PIES, which goes further in addressing the entire learning process and facilitates the involvement of all stakeholders in that process.

Rather than reflecting the housing of extensive services within one large platform, similar to current LMSs, PIES would instead focus on interoperability and the sharing of numerous smaller applications. PIES would be the connecting centralized portal for managing student-directed instruction, teacher-directed facilitation of the learning process, and the interaction of other stakeholders involved in the learning process, including parents, community members, administration, and other school staff.

PIES would likewise have different interfaces for each of these stakeholders. It would be open in nature, meaning that, while we ideally desire open-source and free software, the focus is on the ability for the end user to customize her experience and on the ability to interoperate with numerous available outside services. This shifts both the complexity and the cost of development of PIES by not requiring a single platform to be developed that can be all and do all services required of a systemic tool for the entire learning process, but instead supporting the quilting together of numerous, individual services, which pieced together and managed by the PIES, still result in the full required functionality. Furthermore, the PIES will be comprised by multiple architectures, bringing together the web-centric nature of connecting cloud-hosted service apps with secure data systems hosted on local central servers.

As detailed in our previous article (Reigeluth et al., 2008), we envision that four primary functions (see Table 1), and four secondary functions (see Table 2) will be necessary for supporting a learner-centered approach to education.

Table 2. PIES secondary functions.

| | |
|---|---|
| 5. Secondary functions | 5.1 Communication |
| | 5.2 General student data |
| | 5.3 School personnel data |
| | 5.4 PIES administration |

### *Record keeping*

The first function manages record keeping for student learning by recording inventories of standards, personal attainments, and personal characteristics. This function will replace the current report card by providing students, teachers, and parents with comprehensive and systematic information about what each student has learned. Rather than artificially decomposing learning into unconnected courses, and assigning students to courses based on age rather than level of knowledge or skill, the new paradigm will instead focus on student mastery of specific skills and knowledge. The standards inventory guides the planning process (function two) by providing information on required standards at the local, state, and national levels level as well as any other specific standards well matched to the individual student's interests or talents.

Based on domain theory (Bunderson, Wiley, & McBride, 2009), these standards will be organized into maps for each domain of learning, including major attainments categorized into pathways for learning and sequenced based on difficulty. The personal attainments inventory also informs the planning process by keeping track of each student's progress toward meeting required or optional standards, serving as a customized mastery progress report. Each attainment will document when the standard was attained and will be linked to evidence of its accomplishment, whether that be formal assessments or original artifacts. Furthermore, users, including students, will be able to have ownership of their artifacts and be able to take their materials with them should they leave the school system or stop using the PIES, a characteristic promoted in the PLE literature and uncommon in CMS.

The personal characteristics inventory will guide planning and the instructional process (function three) by keeping track of the characteristics of each student that may influence learning, such as student interests, learning styles, and so forth. This will help customize instruction for each student while also helping teachers to facilitate the learning process and to quickly familiarize themselves with unfamiliar students.

### *Planning*

The planning function will support the development of a personal learning plan for each student. Instead of students working in courses arranged by age and content domain, which results in creating artificial barriers between domains, as well as forcing students to learn at others' pace instead of their own, PIES will support and help promote transformative, new paradigm approaches to schooling by facilitating individual planning for each student. It will support the student, parents, and teacher to (1) decide on long-term goals, (2) identify current options (attainments) within reach and tied to long-term goals, (3) select short-term goals from these options, (4) identify projects or other forms of instruction tied to these short-term goals, (5) identify other students interested in collaborating on these projects, (6) specify the roles the teacher, parent, and other interested parties such as community members or students might play in supporting student learning on the project, and (7) develop contracts specifying and detailing these choices.

### *Instruction*

The role of a teacher in the a learner-centered paradigm will shift to a facilitator who selects or designs instructional tools for students and guides students in their use (McCombs & Whisler, 1997). Hence, the third function will provide tools to support these activities.

The project initiation tool will guide students and, if necessary, their teacher in understanding the chosen project or problem and how to effectively start it, including providing

guides for collaboration, important milestones, and helpful resources. The instruction, whether housed within PIES or hosted externally but linked to PIES, will be in a variety of formats, including educational simulations and games, tutorials, and WebQuests (any form that serves in mastering attainments, including creative projects such as model building, painting, or creative writing). These repositories of LOs will face the same challenges currently faced; however, this will be addressed by the use of folksonomies where users rate the quality of content on a large scale, coupled with the continued evolution of Web 3.0 (or the Semantic Web), where meta-data are used to convert content to meaningful and retrievable information (Morris, 2011).

The project support tool serves to help students manage the project by checking off project goals and milestones as they are completed, which will also aid in supporting teachers and parents in monitoring students' progress.

The final tool in the instructional function will support teachers, staff, parents, and potentially even students in developing new instruction that can be connected to PIES to create a repository of instructional projects and that fits well with the Web 2.0 focus on user-generated content (Brown & Adler, 2008).



#### *Assessment*

The fourth primary function of PIES will focus on student assessment. The same kinds of authentic tasks used during instruction will be used for student assessment and will serve to have students demonstrate mastery in a variety of authentic contexts until the established criterion for demonstrating mastery has been met. Evaluating student performances will be supported whether or not the performance is done within PIES; a teacher or trained observer (possibly a more advanced student) will assess performances, guided by rubrics for each criterion, and will upload the data to PIES. Frequent feedback will be given, often during the performance itself.

When the criterion for successful performance has been met on the predetermined number of unassisted performances, the summative assessment will be complete, the attainment will be checked off in the student's inventory of attainments, and a link will be provided to the evidence of mastery, all automatically. Finally, the assessment tool will support teachers and others in developing formative and/or summative assessments (tied to the instructional development tool) and in formatively assessing the instruction and assessments themselves.

### *Secondary functions*

The secondary functions of the PIES will not necessarily be directly connected to student learning but will still be required for an effective educational process. The PIES will support communication amongst teachers, parents, students, and other stakeholders, as the learning environment will be extended beyond the school walls, and students will work on projects, and collaborate with other students and even community members at home, at school, or in the community. Securely storing private data for students will be important in order to have health and parental contact information for students, as well as to track the physical location of students within the school facilities through radio-frequency identification or the swiping of magnetic student identification cards because students will no longer be restricted to a single classroom at a set time.

Information on school personnel will also be securely stored, including evidence of professional development and professional excellence, such as exemplary student work,

assigned students, awards, certifications, etc. Finally, it will be important to manage the PIES itself by supporting the administration of data, including restricting or allowing access based on user role.

## Conclusion

Current approaches to learning continue to be largely teacher-centric, relegating the learner to a passive role and treating her as a vessel to be filled with knowledge rather than a critical and creative problem solver. Furthermore, they force variation in levels of mastery amongst students rather than assuring mastery for all. Current approaches are no longer suitable in a post-industrial society and result in failing, or passive and unmotivated, learners.

Bush and Mott (2009) quote former Secretary of Education roundtable findings in arguing that technology has been applied to the learning process rather than being used to transform the process itself. PIES, if fully realized, could serve as the sort of discontinuous, systemic application of technology needed to transform and revolutionize the very process of learning. By supporting the tracking and reporting of individual learner competencies tied to standards, instruction and assessments tied to authentic performances and connected to personalized learning plans, PIES will facilitate the implementation of new paradigm, learner-centered approaches. This will support moving student learning beyond the fuzzy nature of whole course curricula and into specific, demonstrated mastery of skills and knowledge, customized, flexible and learner-driven learning processes, and a paradigm that focuses on individual learning rather than grouping and sorting students. Learning will escape the constraints of the classroom and the walls of the school building, and support will be in place for increased stakeholder (including parent and community) involvement, lifelong and motivated learning.

This article has described PIES as a technology that focuses on providing open, customizable, modularized, and interoperable technology to all aspects of the learning process. We argue that this sort of systemic application of technology is needed to move beyond the current learning processes and truly transform them to learner-centered processes that focus on mastery and promote the skills and lifelong learning needed today.

The design and development of such a technology will likely be expensive. However, this is a chicken-or-the-egg problem. Transformative technology like PIES is needed to successfully implement the new paradigm, but the demand for such a technology will not be strong until many schools implement the new paradigm. Without PIES, schools will find the challenge of the new paradigm daunting and be less likely to make the drastic changes needed to move away from industrial age approaches, but commercial companies are unlikely to commit the resources to develop PIES until they see a large, established market of new paradigm schools.

Open source and distributed development of PIES is one solution to reducing costs, but funding is needed to push the development of this technology. Visionaries are needed who can recognize that the industrial age approach to education has long since reached its peak in effectiveness and that a new paradigm of education is needed. Funds to establish the initial PIES hub and infrastructure will go far in advancing the technology as individual functions and content can be developed by the larger community and integrated into PIES as the user desires as previously described. While initial costs to move to the new paradigm may be high, in the long run, implementing an approach to education with goals that meet our current needs and supporting that approach with the necessary technology will result in reduced costs and significant gains for students, teachers, and all stakeholders in the learning process.

## Notes on contributors

William R. Watson is an assistant professor of Learning Design and Technology and director of the Purdue Center for Serious Games and Learning in Virtual Environments. His research interest focuses on the critical, systemic change of education to realize a learner-centered paradigm, including the application of technology such as video games, virtual environments, and learning management software in order to create customized and personalized learning environments.

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Charles M. Reigeluth is a professor of Instructional Systems Technology at Indiana University, Bloomington. His research focuses on paradigm change in public education utilizing digital technology and brain-based, personalized educational methods. He is internationally known for his work on instructional theories and methods.



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