Teaching, Learning, and the Net Generation:

Concepts and Tools for Reaching Digital Learners

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Information Science
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Published in the United States of America by
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com

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Library of Congress Cataloging-in-Publication Data

Teaching, learning, and the net generation: concepts and tools for reaching digital learners / Sharmila Pixy Ferris.
p. cm.
Includes bibliographical references and index.
Summary: "This book provides pedagogical resources for understanding digital learners, and effectively teaching and learning with today's generation of digital natives, offering a much-needed resource that moves beyond traditional disciplinary and geographical boundaries, bridges theories and practice, and addresses emerging issues in technology and pedagogy"--Provided by publisher.
ISBN 978-1-61350-347-8 (hardcover) -- ISBN 978-1-61350-348-5 (ebook) -- ISBN 978-1-61350-349-2 (print & perpetual access) 1. Educational technology. 2. Generation Y--Education. I. Ferris, Sharmila Pixy.
LB1028.3.T3857 2012
371.33--dc23
2011032912

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

All work contributed to this book is new, previously-unpublished material. The views expressed in this book are those of the authors, but not necessarily of the publisher.

Chapter 3
Personalized Integrated Educational Systems:
Technology for the Information-Age Paradigm of Education in Higher Education

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ABSTRACT

This chapter presents a detailed description of the powerful and necessary role technology can play in higher education in the current information-age. This article calls for a Personalized Integrated Educational System (PIES), a comprehensive and integrated application of technology to the learning process, which will provide four primary roles for student learning: record keeping, planning, instruction, and assessment. Each of these four major roles is described in terms of the functions it provides to support student learning. Finally, secondary roles such as communication and general data administration are described in order to illustrate the systemic nature of PIES technology necessary to fully support the learner-centered approach that is essential in the information-age paradigm of higher education.

INTRODUCTION

Higher education institutions are facing unprecedented pressures for fundamental change. The digital natives or the Net generation think and learn differently than those who grew up without interactive digital technology as an everyday part of life (Prensky, 2006; Beck & Wade, 2004), and they now comprise the student bodies of today's higher education institutions. The manner in which the higher education system will need to reflect the changing cognitive processes of digital natives is critical, and their expectations regarding the learning process reflect this.

DOI: 10.4018/978-1-61350-347-8.ch003

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Oblinger and Oblinger (2005) note that the Net Generation has learning preferences that match their general attributes, including preferences for: working in teams, interactive learning experiences supporting inductive discovery and experimentation, visual and kinesthetic rich learning experiences, clear structure and the opportunity for achievement, and the ability to contribute to issues they perceive as important. These preferences call for engaging and personalized instruction and student choice. However, the current approach of most higher education classes focuses on knowledge delivery through lectures rather than learner control, engagement, and skill building. The enrollment attrition of many institutions attests to the disconnect for many Net Generation students entering higher education and how institutions often fail to retain those students who struggle to achieve in a model designed to sort them into those who can and those who cannot, rather than ensure their learning. With institutions under pressure to cut budgets, class sizes can be large and students lack the personalized attention they need to succeed.

The harsh reality is that with faculty attention stretched between teaching and other responsibilities and large class sizes, the personalization of learning processes for higher education students is not feasible without technology. And yet, the needs of the information age demand a transformation to a learner-centered, personalized paradigm of learning, regardless of the degree that students have grown up using technology.

Although members of the Net Generation are often grouped by age (individuals born after the use of Internet and information technology became commonplace), a more accurate grouping is made by grouping those who are heavy technology users (Oblinger & Oblinger, 2005). This has been confirmed by a number of recent empirical studies and reviews that have found that current higher education students have varied experiences, skills, and perspectives on the use of Internet and computer technology (Bennett & Maton, 2010; Jones, Ramanau, Cross, & Healing, 2010; Kennedy, Judd, Dalgarnot & Waycott, 2010). These differences do not alter the fact that modern society is currently in the information age marked by movements towards knowledge economies, easy access to information, and a focus on customization, collaboration, and complex problem solving, among other attributes (Reigeluth, 1994).

The information age, ushered in by information communications technology, has created new educational needs, tools, and realities. Regardless of whether individuals are heavy technology users, given our increasing reliance on information technology and as more and more people are born into and live in this information-technology-rich environment, the distinctions between those who were raised on technology and those who were not will lesson (Prensky, 2009).

Furthermore, with the existing demands of the information age and its knowledge economy, a new paradigm of education is needed that focuses on ensuring student learning, rather than merely sorting learners. This chapter presents a vision for a systemic application of technology to the learning process to support the learner-centered paradigm of learning necessary to meet the needs of the Net Generation and all students in the information-age society.

BACKGROUND

The new educational *needs* include preparing far more students for the information age, versus the industrial age. The information-age economy now requires students to be prepared for knowledge work (which typically entails solving ill-structured problems), collaboration, initiative, self-direction, systems thinking, use of advanced technologies, widely varying skill sets (which requires customization), and much more (Reigeluth, 1994). Recent educational literature by the American Psychological Association, the National Research Council, and others, have called for a shift to the

learner-centered paradigm of education (Alexander & Murphy, 1993; APA, 1993; Bradford, Brown & Cocking, 1999; Lambert & McCombs, 1998; McCombs & Whisler, 1997; Ormrod, 2008; Watson & Reigeluth, 2008). Learner-centered instructional approaches stress the importance of individual learners and their backgrounds, talents, and needs, while also integrating the best knowledge about learning and instructional methods. The new educational *tools* include computers, mobile devices, and the Internet. The new educational *realities* include the expense of higher education (which has been growing much faster than the rate of inflation – Trombley, 2003) and the expense of moving to a university (which, for those who already have a full-time job, includes giving up or temporarily leaving that job). Furthermore, today's students and members of the Net Generation can no longer be prepared to do one job for their entire careers as the dynamism of modern society requires workers prepared to solve problems and adapt to varied and complex situations using an ever expanding toolkit of skills and knowledge, much of it self-taught.

In response to these unprecedented pressures, new higher education institutions are emerging that offer Internet-based alternatives (such as Phoenix University, Walden University, and Kaplan University), and existing ones are developing online programs (Rudestam & Schoenholtz-Read, 2002). However, the business model of these new universities is fundamentally different from that of the traditional, brick-and-mortar universities. The latter put a lot of money into teachers (professors) but little into course development, whereas the new online universities invest a lot in course development and spend little on teachers. This new business model promises to be far more cost effective, given the new educational tools and realities. But what about quality? Advances in knowledge about learning and instruction, combined with advances in the affordances or capabilities of technology, now allow high quality learning experiences to be offered through this new business model – if the right tools and methods are utilized.

So what tools and methods are useful to support the needs of Net Generation learners and to maximize the effectiveness of all learners? To answer this question, it is important to recognize that (1) students learn at different rates; (2) students have differing amounts of time per day that they can devote to learning; and (3) students have different needs, interests, and talents that influence what they should or want to learn. The first and second issues lead us to recognize that decisions about when a student moves on to the next topic should be determined by level of learning rather than amount of time – by when mastery is reached rather than when the course calendar says to move on. In other words, the concept of semesters or quarters does not serve students well, as students learn at different rates. The third issue leads us to recognize that decisions about what a student learns next should be allowed to vary from one student to another in order to facilitate growth of individual talents and interests. In other words, the concept of a course with a fixed set of content to be learned by all students does not serve students well. Does this mean that we need to do away with semesters and courses in higher education? Only if there is a better paradigm to take their place. So let's explore a vision of what might be better.

Given the new needs of Net Generation learners and the new educational needs, tools, and realities of the information age just discussed, we envision that in the future the majority of higher education will be offered online using the new business model. This means that powerful technological tools and well designed, interactive, learning resources will be needed. We currently see four major roles and many minor roles for technology, all of which should be seamlessly integrated into a single system. Since there is no existing term that communicates all these roles, we propose a new term, Personalized Integrated Educational System (PIES). The major roles for PIES include *record keeping* for student learning, *planning* for student learning, *instruction* for student learning, and *evaluation* for (and of) student learning. The minor roles include communication, PIES ad-

ministration, general student data, and personnel information. These major and minor roles will incorporate technology throughout the entire learning process and allow the learner-centered approach necessary to meet the needs of the Net Generation learners.

FUNCTIONS OF PERSONALIZED INTEGRATED EDUCATIONAL SYSTEM (PIES)

As previously discussed, Net Generation learners have particular learning needs and preferences. The new paradigm of higher education must be learner-centered in order to meet the needs of these students as well as the needs of the information-age society. In order to effectively manage and implement a new-paradigm approach to higher education, technology will be needed to support the entire learning process. We call such a system PIES, and this section describes the functions such a system must offer.

1. Record Keeping for Student Learning

The new paradigm of higher education will require the student, mentor-teacher, and parents[1] to be informed of what the student has actually learned at any point in time. This will be necessary to make good decisions about what to learn next and to assure that progress is continuous and personalized. The PIES Record Keeping tool will replace the current transcript. The transcript only serves to compare one student with another and tells you nothing about what a student has actually learned. In contrast, this tool will provide systematic and comprehensive information about what each student has learned. We imagine that this tool will have three components: (1) a general record of what can be learned; (2) a personal record of what has been learned by each student; and (3) a personal record of student characteristics that influence learning for each student.

1.1 Knowledge[2] Inventory

The purpose of this general record is to inform the planning process (role #2) by providing information about all available knowledge, some of which will be required by a higher education institution for specific degrees or certifications. This information will provide the student, mentor-teacher, and parents with a vision of what should be and could be achieved. Furthermore, the knowledge will be organized into maps for each domain of learning based on Domain Theory (Bunderson, Wiley, & McBride, 2009). Each domain map will include (a) major attainments with boundaries showing the easiest and hardest version of each attainment, (b) categories of attainments, where each category represents a pathway for learning, and (c) a difficulty-based sequence of attainments along each pathway. For each attainment in the map, there will be an indication as to whether or not it is required for a given degree or certification, and if so, what level of difficulty is required. In essence, the Knowledge Inventory will present a list of things that should or could be learned, along with levels, standards, and/or criteria at which they should or could be learned.

1.2 Personal Attainments Inventory

The purpose of this personal record is also to inform the planning process (role #2), only it will do so by keeping track of each student's progress in meeting the required and optional standards, and therefore what is within reach for the student to learn next. It will serve as a customized mastery progress report to the student, mentor-teacher, and parents. In this tool, attainments will be checked off as they are reached, and if any are not listed in the Knowledge Inventory, they can be added to the Personal Attainments Inventory. Each attainment

will be documented and reported by date attained, and the record will identify any required knowledge (in the Knowledge Inventory) that is overdue and what knowledge is due next in each domain. Each attainment will also be linked to evidence of its accomplishment, ranging from original artifacts with a formal evaluation, to summary data from a simulation-based performance test. Given this information, the student will be able to easily generate different kinds of portfolios for different purposes by pulling out selected attainments and artifacts. All the information recorded, including the attainments and evidence, will have flexibly controlled access to protect the learner's privacy.

1.3 Personal Characteristics Inventory

This personal record is intended to inform both the planning process (role #2) and the instructional process (role #3). It will keep track of each student's characteristics that influence learning, such as learning styles, profile of multiple intelligences, student interests, major life events, and so forth. These data will be convenient to refer to when major decisions about learning objectives and goals are to be made by/for the student and will be especially useful for teachers who are not familiar with the student. They will help mentor-teachers to customize each student's learning plan to best suit his or her interests, learning styles, life experiences, and educational experiences. But the Personal Characteristics Inventory will also be an effective tool to customize the instruction itself. The student data will be fed into computer-based tutorials, simulations, and other computer-based learning tools to automatically tailor appropriate parameters of the instruction for each student. And the teachers will refer to these data to improve the way they coach and advise the student during projects and other instructional events.

Clearly, a customized paradigm of education requires keeping a lot of records. Technology can tremendously alleviate the time, drudgery, and expense of maintaining and accessing those records. The record-keeping tool will provide systematic and comprehensive information for customizing the learning process, including the Knowledge Inventory (what is to be learned), the Personal Attainments Inventory (what the student has learned), and the Personal Characteristics Inventory (the student's characteristics that influence instruction). It will facilitate collaborative efforts among students, teachers, the community, the state, and the nation to ensure that appropriate standards are being met while customized attainments are achieved by each student. And it will facilitate customizing the instruction to each student's individual needs.

2. Planning for Student Learning

If Net Generation students are educated in a paradigm suitable to meet their needs, instruction must be customized for each individual learner, an approach that is necessary not only for attainment-based learning, but also to meet the preferences of Net Generation learners (Oblinger & Oblinger, 2005). Customized instruction requires a personal learning plan (PLP). Assisting with development of that plan is the second major role for PIES. This planning will usually be done in a meeting (virtual or face-to-face) between the student and his or her mentor-teacher, while using the planning tool.

This planning tool will have many functions. It will help the student and mentor-teacher to (1) decide on *long-term goals*; (2) identify the full range of attainments (*current options*) that are presently within reach for the student that could help meet those long-term goals; (3) select from those options the attainments that they want to pursue now (*short-term goals*), based on requirements, long-term goals, interests, opportunities, etc.; (4) identify *projects* (or other means) for attaining the short-term goals; (5) identify *other students* who are interested in doing the same projects (if desired); (6) specify the *roles* that the mentor-teacher,

parent, and any others might play in supporting the student in learning from the project; and (7) develop a *contract* that specifies goals, projects, teams, roles, deadlines, and milestones.

2.1 Long-Term Goals

Many students graduate from higher education not knowing what they want to do with their lives. We propose that students should be encouraged to think about life goals (not just career goals) from the beginning of post-secondary education (if not earlier) and should be encouraged to be constantly on the lookout for better goals. Given the Net Generation's desire for personally meaningful and structured learning (Oblinger & Oblinger, 2005), this function is not only necessary for effective learning, but will also help Net Generation students understand what they must learn and why. A study by Harackiewicz, Barron, Tauer, Carter and Elliott (2000) found that setting achievement goals has a positive effect on how students approach, experience, and perform in class. Setting of goals – a means to building self-efficacy – proves to be a highly effective method for encouraging self-regulated learning (Schunk, 1990, 1991; Zimmerman, 1990). Long-term goals can help students pick motivating topics to study and give instrumental value for much of what they study. Therefore, the planning tool will help a student and mentor-teacher to develop and revise, in a collaborative fashion, the student's long-term goals. It will include access to motivating, informational, interactive multimedia programs about different careers and ways of life.

2.2 Current Options

Another important function in educational planning is to know what attainments are within reach, given what the student has already learned. The planning tool, therefore, will access the student's Personal Attainment Inventory and compare it to the general Knowledge Inventory to automatically identify the full range of attainments that are current options for the student. This will be the student's world of possibilities for her or his next PLP.

2.3 Short-Term Goals

The student's PLP will specify what learning goals the student will accomplish during the next contract period (variable, but typically about three months). Thus, the planning tool will help the student and mentor-teacher to select from the current options the attainments to pursue now, based on requirements, long-term goals, interests, opportunities, and so forth, providing the structure desired by Net Generation learners (Oblinger & Oblinger, 2005). These goals typically will come from many different competency areas or subject areas. This is a crucial function of the planning tool because it will set the goals for the next learning contract, or PLP.

2.4 Projects

Having identified the ends for the PLP, the next step will be to identify the means, so this is another function for the planning tool. Typically, projects will be used as the means, an active form of instruction preferred by the Net Generation (Oblinger & Oblinger, 2005), but other options will sometimes be available (e.g., readings with discussions, or tutorials). The tool will help the student and mentor-teacher to identify projects or other means available in the college or community or online that will enable the student to attain the short-term goals. This tool will identify, say, a dozen projects rank ordered by the number of short-term goals (attainments) that each addresses. The student will then select the projects that are most related to their interests and long-term goals and cover all the short-term goals. Depending on the scope of each project, a student will undertake

from one to about five projects during a single contract period. Finally, this tool will also have a feature that allows teachers and community people – and even students – to post projects that they have developed or are sponsoring.

2.5 Teams

"The unfolding of the self always grows out of interaction with each other" (Ranson, Martin, Nixon, & McKeown, 1996, p. 14). Collaborative learning is a powerful form of learning (Gokhale, 1995), and a form preferred by the Net Generation (Oblinger & Oblinger, 2005). Thus, in most cases, students will work together in small teams on their projects (virtually or face-to-face). This means that another important function for the planning tool is to identify other students who are interested in working on the same project at the same time. Friends will sometimes choose projects so that they can work together, but mentor-teachers will only allow so much of that and will also require their students to work with students they do not know, seeking to create teams that are highly diverse (age, race, gender, socio-economic status). The planning tool will also use personality inventories (e.g., Myers-Briggs) to help students understand why their teammates may behave quite differently and how to deal with that.

2.6 Roles

In addition to collaborating with peers, students will receive support from their teacher, their mentor-teacher, and perhaps various others (like community members or task experts). Therefore, another function for the planning tool is to help the teacher and mentor-teacher to define what they will do to support the student's learning on each project. Roles of the students and others who are not present in the planning meeting between the student, teacher, and mentor-teacher will be determined with help from the contract-planning tool.

2.7 Contracts

The final step of the planning process will be to create the contract that contains the PLP. These contracts provide the structure many Net Generation learners crave (Oblinger & Oblinger, 2005). Reigeluth and Garfinkle (1994) identify learning contracts as a written agreement that "will serve a planning and monitoring function" (p. 64). A learning contract will essentially be an agreement between a student, teacher, and mentor-teacher that specifies the goals that the student wishes to achieve, the means (primarily projects) that will be used to achieve them, the teacher's and mentor-teachers' roles in supporting the student, and the deadline for completing each project (negotiated with the teammates for each project). Students and mentor-teachers, as Reigeluth and Garfinkle note, will meet once every contract period (three months or so) to review the results of the previous contract and plan a new contract for the next period. Typically there will be a separate contract for each project during the period.

Clearly, the planning tool will be crucial to the instructional process in an information-age educational system. It would likely be impossible to customize the learning experience for each student without it. It will specify what the student, teacher, and mentor-teacher will do, and it will be instrumental for monitoring the student's progress.

3. Instruction for Student Learning

Net Generation learners prefer engaging, collaborative, customized, and meaningful instruction (Oblinger & Oblinger, 2005). In a learner-centered paradigm, all learners should be given choice in their learning process, and therefore, an important role of PIES is managing learners' instruction.

Once a contract has been developed and signed, the projects need to be conducted. This is when instruction, broadly defined as "anything that is done purposely to facilitate learning" (Reigeluth & Carr-Chellman, 2009), will take place. To

implement the kind of learner-centered instruction required for the information age (S. L. Watson & Reigeluth, 2008), the teacher will not be able to do all the teaching. The teacher's role will change to selecting or designing mostly Web-based instructional tools for students to use and coaching students during their use of those tools. So what functions need to be performed in this third major role for PIES? We see four functions: (1) project initiation; (2) instruction; (3) project support; and (4) instructional development. Combined, these four functions will ensure that PIES truly supports learner-centered instruction in the information-age paradigm of education.

3.1 Project Initiation

The project initiation tool will help the teacher and students to get started on each project. Depending on the age of the students, this tool will be used by the student, teacher, or both. The primary functions it serves will be to introduce the students to the project or problem to be solved (its goals and initial conditions) and help them get organized. They will already know a little about the project from the planning tool, and they will have already set a deadline for completing the project with their teammates. This Project Initiation tool will provide access to more information about the project (or problem) and will help the teammates identify tasks to perform, how they will work together on each task (collaboratively on the same tasks, or cooperatively on different tasks), the resources they will need, and milestones for different tasks during the project (time management). This information about the project will often be provided in a multimedia simulation such as Bransford's STAR LEGACY, which provides (a) "look ahead and reflect back binoculars," (b) an inquiry cycle that involves presenting a challenge, generating ideas, exploring multiple perspectives, researching and revising, testing your mettle (formative assessment), and going public, (c) additional inquiry cycles for "progressive deepening," (d) general reflection and decisions about legacies, and (e) assessment (see Schwartz, Lin, Brophy, & Bransford, 1999).

3.2 Instruction

Once the students get organized on a project, they will begin working on it. As they work on it, they will encounter (identify) attainments they need in order to be successful. These will include such attainments or components of an attainment as: information that needs to be memorized, understandings that need to be acquired, skills that need to be developed, and various kinds of affective development. Some of these attainments and components will be developed by leaving the "project space" (which often occurs in a computer-based simulation) and entering the "instructional space" comprised of customizable learning objects of various kinds (Gibbons, Nelson, & Richards, 2002; Hodgins, 2002; Wiley, 2002), including mini-simulations, tutorials, Webquests, and drill-and-practice (some in the form of educational games), that allow full development of an individual attainment or component, complete with its "automatization" (Anderson, 1983; Salisbury, 1990), if appropriate for mastery of it. Some attainments and components will also be acquired by using research (information-access) tools on PIES. Most, but not all, such attainments and components will be developed in PIES. Some may exist as resources offered by businesses and other community organizations, but those resources will be located primarily through PIES. Once those attainments and/or components have been mastered, the student will reenter the project space and continue work on the project, cooperating or collaborating with teammates, as appropriate. Debriefing and reflection on the project activities at the end of the project – and periodically during the project – will also be important to the learning process and will be facilitated by the instructional tool.

3.3 Project Support

This function of the instructional tool has two purposes: helping the students to manage the project and helping the teacher and mentor-teacher to monitor and support the students' work on the project. Students will review project planning materials and check off project milestones and goals as they are completed. The system will alert teachers and mentor-teachers to student progress on the project, such as notifying teachers of the submission of project deliverables or the completion of project milestones, in order to encourage and guide the student's progress, make recommendations, and facilitate the completion of the project. The teacher will also suggest resources or provide comments on submitted project deliverables to guide the student while he or she continues to work on the project.

3.4 Instructional Development

The final function for the instructional tool is to support teachers, staff, mentor-teachers, and even students in the development of new instruction – projects, learning objects, and other instructional tools. PIES will contain a large repository of instructional tools that provide varied approaches to instruction. However, it seems that there will never be enough powerful instruction for all learners in all contexts. Therefore, an important feature for PIES will be to support the development of new instructional tools, which will often serve as learning objects, and will then be added to the repository and evaluated for effectiveness (see next section), ensuring that instruction continually improves. A powerful authoring system will support the creation of these new instructional tools by providing instructional guidance and even automatic development and programming of the instruction, similar to Merrill's (M. David Merrill & ID2 Research Group, 1998) ID Expert. User-created content is an everyday reality in today's information age, with popular video games including "modding" toolkits to allow players to create their own versions of games, and Internet users developing their own content in the form of wikis and blogs, as well as videos and podcasts which they upload to share with others and continue the cycle of development and modification (Brown & Adler, 2008). This instructional development tool will provide similar support in customizing and creating customized instruction and projects. Furthermore, the easy and efficient application of learning object standards to created instruction will be a necessity in order to better share learning objects and evaluate their suitability and interoperability for different platforms (Connolly, 2001).

This section has highlighted the instructional functions that PIES should provide. These include (a) introducing the project to a learner (or small team), (b) providing instructional tools (simulations, tutorials, drill & practice, Webquests, research tools, communication tools, and learning objects) to support learning during the project, (c) providing tools for monitoring and supporting student progress on the project, and (d) providing tools to help teachers and others develop new projects and instructional tools.

4. Assessment for (and of) Student Learning

The assessment tool will be integrated with the instructional tool, so that teaching and testing will be fully integrated (Mitchell, 1992; Wiggins, 1998). To accomplish this, we envision the assessment tool fulfilling six functions: (1) presenting authentic tasks for student assessment; (2) evaluating student performances on those tasks; (3) providing immediate feedback to the student on the performances; (4) assessing whether or not an attainment has been reached; (5) developing student assessments; and (6) improving instruction and assessment.

4.1 Presenting Authentic Tasks

The same authentic tasks that are used during instruction will be used for student assessment. The project itself will be an authentic task. And so will the instances (or cases) used in the "instructional space," where much of the learning occurs. Those instances, however, will not be restricted to the project that motivates the learner to master the attainments. To truly master an attainment, the learner must be able to use it in the full variety of situations for which it is appropriate. Those authentic situations will be used as the instances for the demonstrations (or examples) and applications (practice) of the attainment. There will be a large pool of authentic instances to draw from that will include all the types of instances. And the learner will continue to work on the instances until an established criterion is met across all the desired types of instances. In this manner, the applications will serve a dual role of instruction and assessment (both formative and summative). Simulations will often be used to enhance authenticity. Authenticity of applications will enhance transfer to real situations in which the attainments are needed. Authenticity will also help students understand *why* they are learning a particular attainment, and how it could be useful to them. This will help students become and stay motivated to learn (Frederickson & Collins, 1989).

4.2 Evaluating Student Performances

Whether in a simulation or a tutorial or drill and practice, the assessment tool will be designed to evaluate whether or not the criterion was met on each performance of the authentic task on PIES. If the performance is not done on PIES, then a teacher or other trained observer (who could even be a more advanced student) will have a handheld computer with a rubric for evaluating success on each criterion, and that information will be uploaded into PIES.

4.3 Feedback

Research has shown that frequency of *formative assessments* is positively related to student achievement (see, e.g., Marzano, 2006). Thus, based on the evaluation of student performance, the learner will be provided immediate feedback of either a confirmatory or corrective nature. This immediate feedback will often even be given during the performance for the greatest effect on learning, in which case it will be similar to coaching, scaffolding, or guiding the learner's performance, or it could be given at the end of the performance. This will be most cost-effective if done by a computer system online, which requires the kind of up-front investment in instructional development that is characterized by the new business model for online universities.

4.4 Certification

When the criterion for successful performance has been met on x out of the last y unassisted performances, the *summative assessment* will be complete and the corresponding attainment will be automatically checked off in the student's personal inventory of attainments, and a link will be provided to the evidence for that attainment (e.g., in the form of test results or artifacts produced). This avoids the problem so prevalent in collaborative problem-based learning – that a group product is not a good measure of the learning of each individual member of the group, for it is common that different students contribute different skills to the overall performance. Also, in cases where feedback is given during a performance, successful performance will not count toward the criterion. To count, the student's performance must be unassisted.

4.5 Test Development

The assessment tool will also serve the function of supporting teachers and others in the development

of formative and summative assessments for new instruction. Due to the integration of instruction and assessment in PIES, the test development tools will also be integrated with the instructional development tools, which will deal with feedback. For certification, the major function will be to help the developer identify the criterion for attainment and develop any necessary rubrics, so the tool will tap into information in the Knowledge Inventory described earlier and will help the test developer link the rubrics to the knowledge standards.

4.6 Improvement of Instruction and Assessment

The final function of the assessment tool will be to formatively assess the instruction and assessments in PIES. It will do so by automatically identifying areas in which students are having difficulties, and it will even have diagnostic tools that offer a menu of suggestions for overcoming those problems. Those diagnostic tools will include proven principles of instruction, such as those represented by Merrill's (2009) "First Principles of Instruction."

INTEGRATION OF THE FOUR ROLES

These four roles for student learning will be seamlessly integrated. The record-keeping tool will provide information automatically for the planning tool, which will identify instructional tools that are available. The assessment tool will be integrated into the instructional tool as well. In addition, the assessment tool will feed information automatically into the record keeping tool. Finally, there will be many other secondary roles or functions for PIES that will support these four major roles for student learning, as explained in the following section.

5. Secondary Roles

The final set of roles necessary for PIES will encompass secondary roles, or functions, which are not necessarily directly related to student learning; although some, such as communication functions, can be used for learning. These functions are organized into four kinds: (1) communication; (2) general student data; (3) personnel information; and (4) PIES administration. While these functions will not always directly deal with student learning, they will nevertheless be necessary functions for PIES to be truly systemic in nature and provide the functionality needed to manage the entire learning process for a higher education institution.

5.1 Communication

Communication functions are essential in supporting a learner-centered environment, as they allow teachers to communicate and collaborate with other teachers and staff, with their students, with their students' parents, and with members of the community and other stakeholders in the learning process. Students will communicate and collaborate with each other and will contact their teachers for help, and parents will be able to check on their children's progress and be more involved in their learning. Being able to communicate remotely via Internet technologies will allow education to extend beyond the walls of the classroom. Therefore, PIES will support Web communication technologies such as these. Furthermore, Web 2.0 technologies that allow for user-created content have become increasingly popular, and the Web has become a participatory social space to such a degree that *Time Magazine* named their person of the year for 2007 as "You" (Grossman, 2006). Furthermore, these Web 2.0 technologies such as wikis, blogs, and podcasts, and video sharing sites such as YouTube have helped to increase the participatory nature of learning (Brown & Adler, 2008). Additionally, PIES support for such addi-

tional Internet technologies as Webpage creation, discussion boards, and whiteboards will provide valuable tools for collaboration and communication. The inclusion of RSS feed support (Duffy & Bruns, 2006), which allows users to subscribe to favorite Websites and be notified of updated content, will put further power for communicating and organizing information into the hands of all users and stakeholders. While the use of these Web technologies will not always be applied directly to the learning process, more and more researchers are discussing the application of wikis (Augar, Raiman, & Zhou, 2004; Duffy & Bruns, 2006; Lamb, 2004), blogs (Duffy & Bruns, 2006; Williams & Jacobs, 2004), podcasts (Lum, 2006), and video-sharing sites such as YouTube (Bonk, 2008) to education, so these Web 2.0 technologies will certainly be powerful tools for instruction as well as communication.

5.2 General Student Data

One type of data PIES will be responsible for handling is student data (aside from data related to student learning). These data will include the student's name, address, birth date, parent information, health information, attendance, and so forth. However, in supporting the learner-centered paradigm of education, PIES will also handle student information necessary for supporting information-age higher education, which has moved beyond the current constraints of grade levels, class periods, and so forth. Therefore, PIES will also manage such student data as who the student's mentor-teacher is, records of major life events (which may be important for the mentor-teacher to have knowledge of), work experience, current employer (if any), what learning community the student belongs to, and community organizations he or she is involved with. PIES will protect and restrict access to private information based on the user's role in order to adhere to FERPA and other regulations and ensure appropriate user privacy. In sum, the management of student data will be a key function of PIES. PIES will gather, secure, and allow easy management of data such as those described above in order to effectively support the truly learner-centered environment necessary to meet the needs of today's learners.

5.3 Personnel Information

The third secondary function is the management of information about personnel in the post-secondary institution. As PIES will be systemic in nature (Watson, Lee, & Reigeluth, 2007; Watson & Watson, 2007) and responsible for managing the entire learning process of a learning organization (Szabo & Flesher, 2002), it needs to be capable of managing *all* of the data related to learning, including those of the personnel. These data will include general information, such as name and address, but also data related to learner-centered instruction, such as assigned students, certifications and awards received, and professional development plan and progress. These data will also serve the teacher in providing evidence of excellence by identifying awards and recognitions received by students and storing samples of exemplary student work and evidence of learning. Additional information will be tied directly to the teacher's instructional activities and will include learning objects, other instructional components, and assessments developed by the teacher, as well as records of student evaluations performed by the teacher. Proper management of this information by PIES will support the new role of teachers as facilitators, coaches, and mentors that is required in a learner-centered environment (McCombs & Whisler, 1997).

5.4 LMS Administration

Another secondary function focuses on administration of PIES itself. As software that manages the entire learning process, PIES will necessarily gather and store a great deal of data, including some that is sensitive. An important feature of PIES

will therefore be supporting the administration of these data and providing and restricting access to them. While it will be extremely important that data such as medical records and social security numbers be kept secure by PIES, it will also be important that proper access to data and PIES' reporting features be handled in a consistent and efficient manner. The ability to input, retrieve, and update data will be managed by user role. Therefore, some teachers will have access to some of a student's personal information, such as attendance records, parents' names and contact information, and so forth; and some support personnel, such as a health professional and a guidance counselor, will have access to other personal information, such as physical and mental health records. Furthermore, data will be kept not only on students, but also on teachers and staff. It is therefore very important that PIES will offer strict security while still providing appropriate access to data in order to effectively support the information needs of the institution and its personnel.

This section has highlighted some secondary functions that PIES will provide. These include functions related to communication, general student information, personnel information, and PIES administration, and there are certainly others that we have not mentioned here that could be included. However, it is not appropriate for PIES to address administrative functions, such as budgeting, payroll, and purchasing, as those are not directly related to the student learning process.

ARCHITECTURE AND INTERFACE

An important aspect of PIES will be its open architecture and customizable user interface. PIES, as we have described it, will serve a number of roles and must incorporate features to suit each role. Rather than a mammoth, static application, the quality, effectiveness, and development cost of PIES will best be served through a focus on openness, modularity, interoperability, and customization. These traits, demonstrated by popular Web 2.0 tools (in contrast with institution-centric and course-focused traditional technologies, such as Course Management Systems), have resulted in increasing calls for similar educational tools that also share these attributes.

Open technology is defined as "tools, processes, and frameworks that interoperate in an open fashion to create and deliver content that is itself accessible, flexible, and repurposable" (Bush & Mott, 2009, p. 3). Openness can have different meanings when referring to technology, from being free to the user like open educational resources, or providing access to view and modify source code, like open source programming; however, the key concept is the focus on modularity, customization, and interoperability (Bush & Mott, 2009). Ideally, PIES will be open source, allowing institutions to customize and modify it to best suit their specific needs. Furthermore, by being open source, PIES will be developed by a community rather than a single institution, spreading development costs, promoting innovation, and allowing it to be offered for free or at a reasonable cost.

Customization will not be limited to developers customizing PIES to suit their own needs, but will also entail support of user customization. Web 2.0 tools, such as iGoogle and Facebook, serve as good models for how, even if not offering full access to source code, Web applications can be interoperable through proprietary Web Application Programming Interfaces, which allow developers to develop new modules or add-ons to existing programs. As PIES has a wide range of necessary features, by taking a modular approach with a focus on interoperability, developers will contribute modules that together combine to form PIES as a whole. This approach can be seen in the variety of Web apps available for iGoogle or Facebook, allowing users to customize both the interface and the available features to suit their specific needs.

By allowing users to customize their own use of PIES, it will promote ease of use and effectiveness by allowing user control. Just as a user

in iGoogle can drag in news subscriptions from various sites, their local weather report, daily quotations, email, and even documents they are sharing and editing, a student in PIES will be able to customize it by managing its layout, projects she is currently working on, resources she is currently using, a portfolio of her completed work, her personal learning plan, a list of her targeted learning attainments, messages, alerts, and other forms of communication, and application modules she is using for the various group and individual projects she is working on.

PIES will not only offer a significant change in how technology can be used for instructional and administrative functional purposes in higher education, but will also offer an extensive move away from current educational software to an open and modular architecture and customizable interface that will result in an efficient, effective and innovative system that fully meets all of its users' educational needs.

The learner-centered paradigm of education focuses on developing learners who are self-directed, critical thinkers, with strongly developed communication, collaboration, and problem-solving skills. The instruction function supports tailoring the instruction to the ways that digital natives think. Also, the evaluation function supports the attainment of whatever outcomes the professor and student believe are important. By supporting, and indeed making possible this sort of environment, PIES lays the foundation for a system of education that meets the needs of the modern global society and its digital native learners.

FUTURE RESEARCH DIRECTIONS

Higher education is already in a significant state of change due to the influx of Net Generation learners, and trends reflect this. Most institutions now offer online or blended courses, and the use of course management systems (CMSs) such as Blackboard, Moodle, and Sakai is common practice. These technologies seek to help students and instructors manage the learning process within the course. However, the course-centric nature of these technologies not only breaks student learning into courses but also remains largely teacher and institution-focused (Attwell, 2007; Bush & Mott, 2009; Weller, 2009).

Recent trends show a rejection of this model and the call for customizable and personalized approaches to learning management, such as the use of personal learning environments (PLEs) that better suit the needs and expectations of Net Generation learners (Mott & Wiley, 2009; Wilson et al., 2006). PIES reflects this trend towards customizing and personalizing the learning process for each learner and granting more self-directed learning (learner control).

Significant challenges remain, and future research is needed to realize PIES and adopt a new paradigm of higher education that meets the needs of the Net Generation and the information-age society. First, significant research and development will need to be done in order to understand how to best develop PIES. Given the potential costs and complexity of such a systemic technology, we recommend a focus on modular and open-source architecture, allowing for the development to be spread out among developers and over time. We stress the need for funding to support such an effort.

Research is also needed on the design of the instructional component of PIES. Research on how to best design the project space and instructional space will help ensure that instruction facilitated through PIES is of high quality. Furthermore, research on the design and development of an avatar to seamlessly integrate the project and instructional spaces will be needed. Research is also needed on how the teacher's role should change to support Net Generation students' learning through PIES.

Finally, for PIES to support the learner-centered paradigm of education so important for the information age and Net Generation learners, higher education institutions will need to transform their organizational structures and stakeholder roles. Research will be needed on how to support higher education institutions as they transform from their

current systems focused on comparing and sorting students through time-based student progress to a mastery-focused paradigm that more clearly defines what skills and knowledge will be gained and focuses on helping students gain and demonstrate mastery of them. Considerable research is needed on professional development for the new teacher roles, including helping faculty to evolve their mindsets about education and using PIES to support the management of the entire learning process.

CONCLUSION

It should be apparent that technology will play a crucial role in the success of higher education institutions in the information-age, particularly given the needs and preferences of the Net Generation. It will enable a quantum improvement in student learning, and likely at a lower cost per student per year than in the current industrial-age paradigm. Just as the electronic spreadsheet made the accountant's job quicker, easier, and less expensive, the kind of PIES described here will make the teacher's job quicker, easier, and less expensive.

PIES fills a primary necessity for truly learner-centered instruction by freeing teachers to take on their new roles in a learner-centered environment: facilitators, counselors, and coaches, rather than being the main source of instructional content (McCombs & Whisler, 1997). In order to support this, PIES will provide a variety of instructional features that allow teachers to truly customize learning for each learner, and to facilitate choice and control for the learners as they work towards mastery of required attainments and deep knowledge of all standard subjects and skills. PIES will support students directly in their new roles, as active agents of their own learning (Schlechty, 2002).

However, such dramatic changes in the roles of teachers, students, and technology are not easy to navigate. They will be easier for online universities using the new business model. Traditional higher education institutions will require dramatic changes in mindsets about education for all their teachers, administrators, and staff, and this will require a systemic transformation process that is carefully conceived and executed. The problem is that paradigm change is a time-intensive and therefore expensive process that requires considerable resources as well as considerable expertise in the transformation process. Higher education institutions are indeed facing unprecedented pressures for fundamental change, and those that have sufficient vision and agility will make the necessary investment to transform themselves and their business model, while many others will likely become obsolete.

ACKNOWLEDGMENT

This chapter is an adapted version of the article, "Roles for technology in the information-age paradigm of education: Learning Management Systems," authored by Reigeluth, C.M., Watson, W.R., Watson, S.L., Dutta, P., Chen, Z., & Powell, N.D.P. and published in 2008 in *Educational Technology, 48*(6), 32-39. It has been adapted to focus on higher education.

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KEY TERMS AND DEFINITIONS

Educational Technology: The application of soft processes and hard products, including but not limited to computer technology, for educational purposes.

Educational Software: Computer software for education.

Information Age Society: A knowledge and information based society.

Learner Centered Paradigm of Education: An approach to education that places the learner as the focus of the educational process and mission, supporting customized and personalized approaches to learning and involving the learner as a co-collaborator in the learning process.

Learning Management Systems: Educational software that manages the entire learning process.

Personalized Integrated Educational Systems: A proposed new technology that is open, customizable and systemically integrates into the entire learning organization and all learning processes, including the record keeping, planning, instruction, and assessment for student learning

as well as secondary functions for managing the entire learning process.

Systemic Change: The approach to change that seeks to utilize systems thinking to design a new system rather than merely alter an existing one.

ENDNOTES

1 Parents are included throughout this chapter if certain conditions are met, such as the student is being claimed as a dependent on income tax returns, the parents are paying for the student's education, and/or the student wants the parents involved.

2 Knowledge is used in the most generic meaning of all that one can learn. It includes everything in the cognitive, psychomotor, and affective domains (skills, understandings, information, attitudes, values, etc.).