Paradigm Change in Education

Introduction to Special Issue

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Guest Editors

This article sets the stage for this special issue of *Educational Technology* on paradigm change in education. First, it defines paradigm change and presents evidence that it is the only way to improve our systems of education and training at this point in the history of the evolution of society. Second, it gives a brief overview of the likely key characteristics of the new paradigm of education and proposes that this paradigm change is not only possible, but inevitable. Third, it gives a brief glimpse of principles that will guide the paradigm change process. Finally, the organization of this special issue is described, along with a summary of each article.

While the word "paradigm" is greatly overused, we believe it communicates most effectively the nature of change that is so desperately needed in educational systems today. Paradigm change stands in contrast to piecemeal change, in which minor modifications are made to parts of a system, while the structure of the system remains intact. *Paradigm change* is both fundamental and comprehensive. A change in one part of the system is so fundamental that it is incompatible with many other parts of the system, so those parts must also undergo fundamental change. "In education, [paradigm change] must pervade all levels of the system: classroom, building, district, community, state government, and [to a lesser extent in the United States] federal government" (Reigeluth, 1994, p. 3). Examples of paradigm change can be found in all aspects of life, as shown in ***Table 1***.

When a system's environment is stable, piecemeal change is appropriate, but when there are dramatic changes in a system's environment, paradigm change is needed. The Industrial Age brought great changes to the needs and conditions for educational systems, making the one-room schoolhouse obsolete. The Information Age is ushering in even more dramatic changes that are making the factory model of schools obsolete.

For example, during the Industrial Age, manual labor was the predominant form of work (Reigeluth & Karnopp, 2013). There was no need to educate most children to high levels, nor could we afford to. Thus, the factory model of schools was designed to sort out the slower students and promote the faster ones for higher education to become managers and professionals. Student progress was based on time rather than learning, so the slower students accumulated learning deficits that condemned them to later failure. Tests were norm-referenced (comparing student performance to that of other students rather than to a standard) to make it easier to flunk out the slower learners. The "hidden curriculum" focused on compliance with authority and perseverance with boring, repetitive tasks to prepare students for assembly lines.

Now, in the Information Age, knowledge work is becoming more common than manual labor. Also, all aspects of life are becoming more complex, from knowledge needed to make good voting decisions in a democracy, to setting up and operating a TV set, complete with DVR, DVD player, gaming console, Internet connection, and surround-sound system. For occupational, civic, and quality-of-life reasons, far more students need to be educated to much higher levels. The educational paradigm needs to be transformed from sorting to learning.

Fundamental to these changed needs and conditions is the recognition that people learn at different rates and have different learning needs, yet the factory model of schools requires students to learn the same things in the same amount of time. The teacher's responsibility is to teach the material. If some students don't learn, that's *their* problem. Teachers who want all students to learn face a frustrating up-hill battle because the time-based system does not allow slower learners to succeed. If we truly want to leave no child behind, we must forsake the time-based, sorting-focused system for one in which student progress is based on learning, not time. We must allow faster

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Table 1. Examples of paradigm change.

Paradigms in ...	Agrarian Age	Industrial Age	Information Age
Lighting	Flame	Incandescent bulb	Light emitting diode (LED)
Transportation	Boat, horse	Railroad	Automobile, airplane*
Education	One-room schoolhouse	Factory model schools	Learner-centered education

*While the automobile and airplane were invented during the Industrial Age, they did not take over from the railroad as the predominant paradigm of transportation until the dawn of the Information Age.

learners to move on as soon as they have mastered the current material, and we must not force the slower learners to move on until they have mastered the current material.

The implications of this are huge. As noted by Reigeluth and Karnopp (2013), it requires changes in testing from norm-referenced to criterion-referenced (a different paradigm of assessment!), changes in student records from grades to certifications of attainments (with badges and portfolios), changes in instruction from standardized to personalized (with a personal learning plan for every student), from teacher-centered to learner-centered, from extrinsic motivation to intrinsic motivation (e.g., through project-based learning), from large impersonal schools to small, caring learning communities. It requires changes in the role of teachers from "sage on the stage" to "guide on the side," the role of students from passive learners to active, self-directed learners, the role of parents from cookie-bakers to partners with teachers in helping their children to learn, and the role of technology from use by the teacher (e.g., PowerPoints and electronic grade books) to use by the student (e.g., immersive project-based learning environments with just-in-time tutorial support).

These changes are impossible within the structure of the factory model of schools. The changes are so fundamental that they require fundamental changes throughout the rest of an educational system. Such transformation is a huge undertaking. Some people who recognize the need for paradigm change in education cry out in despair that it is too monumental to succeed—that the barriers are too great. Others believe that such a "disruptive" innovation can only take place outside the predominant systems and will eventually replace them (Christensen, Horn, & Johnson, 2008).

However, many believe that this paradigm change is inevitable, just as the transformation from the one-room schoolhouse paradigm to the factory model paradigm was inevitable. The deeper a society evolves into the Information Age, the more misaligned the factory model will be with its educational needs, and the more damage will be done to that society. Eventually, the situation will get so bad that the transformation will occur. So the relevant questions for the United States today are:

- How long will this paradigm change take, and how much damage will be done to our students, their communities, and our economy before it happens?
- What can we do to accelerate the transformation process?
- What features should the new paradigm have, and what infrastructures need to be built?

The purpose of this special issue is to help stimulate the development of answers to these questions. It attributes particular value to those professionals whose careers are embedded in the field of educational technology. Such technologies make paradigm transformation possible, if they are applied using principles of systems thinking and systems design. Transformation cannot occur without the effective systemic application of instructional technologies. This issue of *Educational Technology* also provides a glimpse into the world of systems thinking and systems design.

Means and Ends

The organization of this special issue is based on the familiar distinction between means and ends, or process and product. The product issue is what the Information-Age, learner-centered paradigm of education should be like. The process issue is how we can help school systems to transform themselves. Initiatives are desperately needed that will advance knowledge about both the product and the process. Fortunately, many school systems have been reinventing themselves, and we can learn much from them

about both process and product. We can also learn much from other organizations that have undergone paradigm change, such as corporations that have "reengineered" (Hammer & Champy, 2001).

Based on these reinvention efforts, the following appear to be some important features of the new paradigm (Reigeluth & Karnopp, 2013):

- attainment-based system (student progress, testing, and student records);
- learner-centered instruction (personalized, project-based, collaborative, and with just-in-time individualized instructional support);
- expanded curriculum (21st century skills and all aspects of child development);
- new roles for teachers (mentors, designers of student work, facilitators of student work, and lifelong learners), for students (self-directed learners, teachers, and collaborators), for parents (actively involved in deciding what their child should learn and helping their child to learn it), for administrators (a support role rather than a command-and-control role), and for technology (a central role in helping each student learn);
- a nurturing school culture (small school size, strong relationships among stakeholders, multi-year mentoring, multi-age student grouping, and intrinsic motivation); and
- organizational structures (a professional model of teacher ownership of their school; choice for students, parents, and teachers; and local and state administrative systems that support rather than control).

The reinvention efforts also provide insights into important principles of the process for transforming educational systems to the new paradigm (Reigeluth & Karnopp, 2013):

- Mindset change about education is the most important result of a transformation process. So it must be a learning process.
- Decision-making about the new paradigm should be made through a consensus-building process. This is another dimension of the learning process.
- Broad stakeholder ownership of the process is important for building commitment, reducing resistance, and enhancing sustainability. It spreads out the learning.
- The transformation process should use a combination of adopting others' ideas and adapting them through invention and designing for the ideal.
- The change process should be comprehensive, addressing work processes, supporting processes, and external relationships, and addressing the instructional system, assessment system, record-keeping system, and so forth.
- Leadership and political support are crucial from all formal and informal groups, with an emphasis on developmental (or servant) leadership.
- Systemic leverage should be achieved by making the most impactful structural changes first and allowing for the gradual emergence of additional changes to support them.
- Readiness, capacity, and culture must be developed before meaningful change can occur.

These and other features of the product and process of systemic transformation are further explored and developed in this special issue.

In This Issue

This issue is organized using four sections, and each section has multiple articles:

- Visions of the New Paradigm (the product issue)
- How to Help School Systems Transform (the process issue)
- Case Studies: What's Happening Now
- Paradigm Change in Other Realms of Education and Training

Each article is highlighted below.

Section 1—Visions of the New Paradigm

Scott Thompson's article, "A Paradigm for Learning in a World of Continuous Change," presents an argument for transforming our educational systems. He points out that while many aspects of our society have transformed to meet the demands of the Information Age, education has not. He argues that schools and school systems must adopt a new paradigm for learning, if they are to remain relevant by preparing children and young people for life and work in the new era.

In her article, "How to Personalize Learning in K–12 Schools: Five Essential Design Features," Dabae Lee provides research-based guidance for five features of truly learner-centered instruction: (1) a personalized learning plan for every student; (2) project- or problem-based learning; (3) competency-based student progress; (4) criterion-referenced assessment for ensuring student learning; and (5) multi-year mentoring of students by a teacher. She describes educational benefits and design principles of each feature.

The article by Charles M. Reigeluth, "The Learner-Centered Paradigm of Education: Roles for Technology," explains very different roles for technology in a transformed education system. Reigeluth argues that, instead of technology almost exclusively serving the teacher for teaching, technology should primarily serve the student for learning. He then goes on to describe four major roles for instructional technology in a transformed school system.

Section 2—How to Transform School Systems

Daniel Kim's article, "Transformational Dialogue for Public Education: Moving from Tweaking to Transforming at the State Level," describes the work he did with the state of Ohio to transform education in that state through a forum called the "Transformational Dialogue for Public Education." His article also provides a clear and compelling glimpse into the world of systems theory and how that theory can inform efforts to transform education.

"Paradigms, Mental Models, and Mind-Sets: Triple Barriers to Transformational Change in School Systems," by Francis M. Duffy, provides a compelling description of paradigms, mental models, and mind-sets as sources of fierce resistance to transformational change by using a religion metaphor to explain the power of the three phenomena.

The article by Sunnie Lee Watson and William Watson, "Engaging At-Risk Populations in the Systemic Educational Transformation Process," argues that marginalized and disadvantaged student bodies in public school districts have very different cultures of learning from mainstream learning communities. They posit that those marginalized student bodies are isolated for convenience in administration and instruction. They present a strong argument for including the disadvantaged student populations in educational systemic transformation efforts.

Section 3—Case Studies: What's Happening Now

Sinem Aslan, Charles M. Reigeluth, and Dee Thomas, in their article, "Transforming Education with Self-Directed Project-Based Learning: The Minnesota New Country School," describe and highlight a school that was transformed to embody principles of personalized learning. They describe four design principles that make the school unique: (1) a small learning community, (2) self-directed project-based learning approach, (3) authentic assessment, and (4) teacher ownership and democratic governance.

Pratima Dutta's article, "Implementing Learner-Centered Educational Strategies: The Bloomington Project School," presents a case study that offers a glimpse into the school's student-centered, collaborative, and interdisciplinary learning and teaching processes; its mastery-based assessment process; and its successful technology adoption and implementation initiative.

Section 4: Paradigm Change in Other Realms of Education and Training

In "Redesigning Higher Education: Embracing a New Paradigm," William R. Watson and Sunnie Lee Watson make a strong case for bringing transformational paradigm change into higher education institutions. They state that higher education is under significant pressure to transform by embracing a new paradigm. Their article explores the current landscape of higher education reform and describes characteristics of a much-needed new paradigm.

"Paradigm Change in Military Education and Training," by Herbert H. Bell and Charles M. Reigeluth, is the final article in the collection. It presents a fascinating and important story about the transformation of education and training in the U. S. military—a transformation that is creating learning opportunities that are tailored to meet individuals' needs wherever they are and whenever they are ready to learn. They believe the result of this paradigm change will be a culture of continuous, personalized learning with learner progress that is based on proficiency and a greater emphasis on technology-enabled immersive learning environments.

Conclusion

In conclusion, we have compiled a collection of articles that provides insights to the nature of the learner-centered paradigm, why it is important, why it is resisted, and how to create it. It is our hope that the articles found in this special issue of *Educational Technology* will inspire instructional technology specialists and policymakers in all settings to learn more about the nature of personalized learning, the dynamics of systems design, and how to create and sustain transformational change in education and training systems. □

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We welcome your feedback on any of the articles in this special issue on paradigm change in education. We were not able within one magazine issue to offer a fully comprehensive treatment of ths important and complex topic, so we welcome any suggestions you may have for future articles or perhaps another special issue on this topic. –CMR & FMD

The Learner-Centered Paradigm of Education: Roles for Technology

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The learner-centered paradigm of education requires very different roles for technology, as well as for teachers and students, compared with the teacher-centered paradigm. Rather than almost exclusively serving the teacher for teaching, technology primarily serves the student for learning. It does so through four major roles: (1) keeping records of what each student has mastered, what is within reach to work on next, and what characteristics each student has that should influence instruction; (2) helping to create each student's personal learning plan; (3) providing an immersive, authentic project environment with just-in-time instructional support; and (4) formatively and summatively assessing mastery of each student's learning goals. Secondary roles and system architecture are also described.

Introduction

Much has been written about new technologies and their potential to improve education, from the computer to the Internet, from tablets to mobile computing, from virtual worlds to intelligent tutoring systems. Yet most of the literature describes these technologies as add-ons to the current paradigm—the teacher-centered factory model of schools—under the rubric of "technology integration." This greatly limits the power of technology to improve student learning. To reach its potential to improve student learning, we must think in terms of "technology transformation"—how it can be used to transform education (Reigeluth & Joseph, 2002).

In the teacher-centered paradigm of education, technology's primary role is to serve the teacher. This is done mainly through tools such as PowerPoints and electronic grade books. As such, technology always plays a peripheral role and is more likely to increase the cost of education than to decrease it. In contrast, in the learner-centered paradigm, technology's primary role is to serve the student. As such, it has the opportunity to play a much more central role, as it does in most workplaces and home offices, and to actually decrease the cost of education, as it has improved productivity in most workplaces.

Key to this changed dynamic for technology is its importance as an *enabler* of the learner-centered paradigm of education. This paradigm has several essential characteristics:

- Student progress is based on learning, not time.
- This requires knowing when each learner has learned (personalized assessment).
- It requires keeping a record of what each learner has learned (personalized recordkeeping).
- It requires a personal learning plan for what each learner will work on next (personalized planning).
- It requires teaching different things to different students at any given time (personalized instruction).

In essence, attainment-based* student progress requires a level of personalization or customization that is difficult, if not impossible, for a teacher to manage well. But technology can help tremendously with all four of these tasks: planning, instruction, assessment, and recordkeeping. In fact, without technology, there is good reason to believe that the learner-centered paradigm cannot reach its potential for helping all students to reach their potential.

When we view technology from the perspective of transformation rather than integration, we open our minds to both needs and possibilities that were unseen before. This article explores both the needs and the possibilities, and it presents a vision of the ways technology is likely to be used, and is already being used, in the new paradigm. It describes four primary roles and six secondary roles for technology based on the seminal article by Reigeluth *et al.* (2008). Note that the present tense is used to describe these roles, but I am not aware of any technology system that currently serves all these roles.

Four Primary Roles

1. Recordkeeping for Student Learning

When student progress is based on learning rather than time, keeping track of what every student has learned is a nightmare for teachers. Technology is ideally suited to save teachers huge amounts of time on keeping

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* I use the term attainments rather than competencies because there are important kinds of learning in addition to competencies, especially in the affective domain, such as attitudes, values, morals, and ethics. Attainments include all kinds of learning and human development.

records of student attainments. The recordkeeping function of technology in the learner-centered paradigm replaces the report card or transcript of the teacher-centered paradigm and has three parts: standards, personal attainments, and personal characteristics.

The **Record of Standards** includes both required educational standards (national, state, and local) and optional educational standards, broken down to individual attainments, which I call "mini-standards," and arranged in learning pathways when mini-standards build on each other, as is done in the Khan Academy (*www.khanacademy.org/about*). The mini-standards are easily accessed by teachers, students, and parents. The recordkeeping tool presents a list or map of mini-standards that the student should or can master, along with levels and criteria at which they can be learned.

The **Record of Personal Attainments** documents what each student has learned. This tool maps each student's progress on the mini-standards listed in the Record of Standards. It shows when a student met each mini-standard, which mini-standards were required versus optional, and what the next required mini-standards are in each area. This record also provides links to evidence of mastery in the form of summary data, original products (an electronic portfolio), and/or comments from the student, teacher, or outside experts.

The **Record of Personal Characteristics** keeps track of each student's characteristics that influence learning, such as learning style, profile of multiple intelligences, student interests, and major life events. This information is used by the system to customize instruction for each student.

2. Planning for Student Learning

In the learner-centered paradigm, developing a personal learning plan, or contract, for all of their students is difficult for teachers. Fortunately, technology is ideally suited to fulfill this role. The planning tool helps each student, parent, and teacher perform these tasks:

a. **Set long-term goals.** Getting students to think about what career they want to pursue allows instruction to address those interests and enhances intrinsic motivation. The tool helps assess student aptitudes for different careers and explore what different careers are like. This tool is used periodically, because student interests typically change quite often.

b. **Set short-term goals.** Decisions need to be made about what to learn next. The planning tool identifies the full range of attainments that are presently within reach for the student, based on the Record of Personal Attainments. It also identifies required standards that should be addressed at this point in the student's development, and it identifies attainments that are instrumental to the student's current long-term goals. The tool helps the student, teacher, and parents select which attainments to pursue in the next contract period, based on requirements, long-term goals, student interests, and opportunities.

c. **Select projects and roles.** In the learner-centered paradigm, projects are the primary vehicles for students to meet their short-term goals. Therefore, the planning tool searches a project bank and presents a list of projects in rank order based on how many short-term goals (mini-standards) each project addresses and how well aligned each project is with the student's interests. The student, teacher, and parents can then choose from the list or design new projects as means for attaining the short-term goals. If the project requires different students to play different roles, then the tool identifies the role that aligns best with the student's short-term goals. After one project is selected or designed, the list is automatically reordered based on the remaining short-term goals. The tool also helps the student, teacher, and parents decide on the number of projects to undertake during the contract period (which typically ranges from four to 12 weeks, depending on the developmental level of the students and the preferences of the school), using the system's data on the average number of hours per week each project has taken, adjusted by the student's history of time required on projects.

d. **Assemble teams.** Given the importance of collaboration and teaming skills in the Information-Age workplace, family, and other walks of life, most projects are team-based. However, students may occasionally choose to do solo projects, especially if they already have well-developed collaboration skills. When team-based is selected, the planning tool identifies other students who are interested in doing the same project. It also allows the student, teacher, and parents to input criteria for selecting teammates, such as current friends vs. unknown students and degree of diversity on such characteristics as gender, race, ethnicity, age, ability, socio-economic status, and personality. Student, teacher, and parents then adjust the resulting rank-ordering of teammates, and the system makes a best-fit selection from all the students' rank-orderings.

e. **Assign roles.** Next, the planning tool helps the student, teacher, and parents come to consensus about how the teacher, parents, and possibly other individuals might support the student in learning from the project.

f. **Develop contracts.** Finally, the planning tool helps the student, parents, and teacher prepare a contract, or set of project plans, that specifies the short-term goals, teammates and their roles, other

support roles, activities, and a timeline for each project they will undertake in the next contract period.

Students in the learner-centered paradigm must learn to manage their time and meet deadlines, just like people do in the post-school working world. But time available for various projects is flexible based on the number of projects each student takes on, and a student's workload during a given period is thereby tailored to his or her abilities.

3. Instruction for Student Learning

Trying to teach 25 students who are all learning different things at any point in time would be very difficult if teachers had to use teacher-centered instruction. But in learner-centered instruction, student teams work largely independently, with coaching. Furthermore, technology can save much teacher time by introducing projects to students, providing immersive interactive environments for conducting the projects (similar to many computer games), providing just-in-time instructional support (e.g., tutorials) during projects, helping students manage their projects, helping teachers monitor student progress, and even helping teachers and/or students develop new projects and instructional support—all in a learning environment that fosters development of relationships among students and with teachers.

Projects. Technology (computers and mobile devices) can provide a powerful, interactive, project environment, often through simulations, virtual worlds, and engaging, interactive video. The project environment can offer natural consequences for actions taken, much like in computer games, and can allow for unlocking of higher levels as students master tasks on a given level. Being able to select projects relevant to their interests and performing many projects through immersive, engaging, interactive, game-like learning environments do much to enhance students' intrinsic motivation.

Instructional support. Technology provides powerful instructional tools—simulations, tutorials, drill and practice, research tools, and communication tools—to support learning "just in time" during a project and allows each student to spend as much time as needed in learning-by-doing (practicing) to attain each mini-standard (much like the education program at the Khan Academy). Different kinds of instructional support are provided for development of different kinds of attainments (such as higher-order thinking skills, deep understandings, memorization, emotional development) and different kinds of learners (based on their learning styles) (Reigeluth, 2012).

While project work makes learning more fun, the instructional support makes the learning experience more effective and efficient and often reduces frustration.

Digital tools offer many benefits, including these:

- They're more dynamic in sight and sound than static resources and thus accommodate a greater variety of learning modalities.
- They offer powerful interaction for active student learning and immediate feedback.
- Internet access connects students and teachers across geographic and cultural boundaries for a greatly enriched learning environment and eliminates the need to physically be in the same place at the same time.
- Staff development is available on demand—even in rural areas where teachers currently receive little support.
- These tools help [teachers] monitor and support student progress on projects, and they help students monitor and reflect on their own progress and manage their time.

Yet high-tech resources are not the only technologies used in the learner-centered paradigm. Low-tech, hands-on resources, like number rods and sandpaper letters (used in Montessori schools), are also useful, especially for younger students, and are selected through the planning tool. Learning resources are frequently designed for several students to use together, to promote learning with and from each other and to build strong relationships among students. Teachers help students, through coaching and tutoring, as they use the resources, and they provide direct instructional support as necessary, complementing the high-tech and hands-on resources.

4. Assessment for (and of) Student Learning

Conducting formative and summative assessments of students on every mini-standard could be a nightmare for teachers in a world where students are demonstrating each attainment at different times and in different ways. Technology helps with these tasks. The assessment tool is fully integrated with the instructional tool. In the instructional support—whether in a tutorial, simulation, or drill and practice—the assessment tool provides formative feedback to the student on every performance, as is done in the Khan Academy.

Also, when the criteria for successful performance have been met on, say, the last 10 unaided performances, the summative assessment is complete, and the corresponding attainment is automatically checked off in the student's Record of Personal Attainments. There is no separate test; the practice is the test, which saves a lot of time that would otherwise be wasted on testing. This is full integration of testing with instruction.

When interactive technology cannot assess a student's performance, an expert observer (perhaps using a handheld device with a rubric for assessment) evaluates the performance and provides feedback. The information from the handheld device is automatically uploaded into the computer system, where it is placed in the student's Record of Personal Attainments.

Beyond student assessment, the computer system automatically analyzes the quality (effectiveness, efficiency, and appeal) of the projects, instructional tools, teachers, and schools; and the information is used for both formative and summative purposes. Finally, technology provides tools to help teachers develop assessments and link them to the appropriate mini-standards in the Record of Standards. These computer-generated assessment tools significantly reduce the amount of student and teacher time that's currently devoted to carrying out assessment activities in the teacher-centered paradigm.

Secondary Roles for Technology

In addition to the primary roles for student learning described above, technology serves these and other secondary roles:

- communications, including e-mail, blogs, Websites, discussion boards, wikis, whiteboards, instant messaging, podcasts, and videocasts;
- calendar and personal planner to help with planning one's time, scheduling meetings, and tracking deadlines;
- help system and tutorials to help users learn all the system's capabilities;
- administrative access to information and authority to input information based on role and information type;
- documenting general student data, such as address, parent/guardian information, teacher and cluster identification, student attendance, and medical information; and
- central resource on educator data, including office address, certifications and awards, professional development plan and records as well as a list of students (and their evaluations and earned awards) and repository of teaching tools they developed.

Integration of Tools

The four major and six secondary roles or functions of technology are seamlessly integrated in a single system, which my research team at Indiana University refers to as a Personalized Integrated Educational System (PIES), though such a system has yet to be developed as far as we know. The record-keeping tool informs the planning tool, which identifies instructional tools available to carry out the plans. Assessment processes are integrated into the instructional tools and feed data to the record-keeping tool. The student, parent, and teacher all have easy access to progress reports on each of the student's projects and on the set of standards and individual attainments (mini-standards) currently being pursued in the student's contract.

Architecture of Tools

PIES will hopefully be Web-based, open-source software, similar to Moodle, making it more affordable. Ideally, it will be possible for districts, schools, and individuals to customize and modify the program for their own needs, and it will be modular so that anyone can create Web apps (similar to iPhone apps for free and fee), including teachers and even students; to support specific needs. Those apps will all be interoperable, so they can share information with each other. Users can customize the look and function of their personal pages (portals into the system), controlling the flow of information into their pages with RSS feeds and e-mail, and easily incorporating such features as blogs, discussion boards, and chats.

Conclusion

It should be clear that technology plays a vital role in the success of the learner-centered paradigm of education. It enables a quantum improvement in student learning and likely at a lower cost per student per year than the teacher-centered paradigm. Without a technology tool like PIES, it will be difficult for teachers and their schools to achieve the kind of improvement in student learning that we so desperately need.

For a system like PIES to be developed, two things are particularly important. First, it is essential to think in terms of the functions required by the learner-centered paradigm of education. Tools developed with the teacher-centered paradigm in mind are unlikely to be helpful. Second, an initial investment is needed to create an open-source, interoperable system into which apps (for fee or free) can be plugged to create an inexpensive, constantly evolving set of tools for students, teachers, and parents in the learner-centered paradigm. Since private companies are unlikely to invest in a free, open-source product, private foundations or government agencies will need to make this initial investment.

The learner-centered paradigm can only reach its potential with a powerful technology system like PIES. Similarly, technology can only reach its potential in the learner-centered paradigm of education. And both can only succeed if educators self-organize into networks that actively promote the development of both. □

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