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Adaptive Learning Technologies: From One-Size-Fits-All to Individualization

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Overview

The quest for pedagogically effective teaching methods that are responsive to learner needs has been going on for several decades¹ and has led to numerous educational models educators often use as new information dissemination technology gains acceptance. With the advent of any such technology, experts predict that this new, and often disruptive, technology will positively impact learning.

For example, with the invention of radio came the prediction that every school would use the educational programming on radio to enhance education. The arrival of television carried the promise that the educational programs would make a major impact on education and eradicate illiteracy worldwide.² There is no doubt that every generation of technology has made some impact, but most often the promises tend to exceed the educational impacts. As we know, the potential of the World Wide Web as an international mode of information dissemination led experts both from educational and commercial sectors to predict that online education would revolutionize higher education. Perhaps this is still in our future, but research conducted by the EDUCAUSE Center for Applied Research (ECAR) concludes that most of the “e-learning revolution (so far) is about convenience and not learning.”³

These examples of the impact of technology on education demonstrate that the introduction of technology is *necessary but not sufficient* to change the paradigm of education. How might technology become an integral part of the pedagogical process to bring about a real shift toward effective education? What kinds of technology systems will contribute to a higher education environment that supports adaptive learning?

The paradigm shift towards adaptive learning systems demands that we take a fresh look at the pedagogical framework for online education. The framework is multidimensional and includes integrated self-diagnostics and feedback mechanisms for identifying learner preferences. Likewise, it requires continuous adjustment of the learning trajectory in order to achieve the best educational performance results.

This research bulletin addresses how technology systems can support online learning in ways that can adapt to the multiple learning preferences, paces, and performance goals of a broad spectrum of learners. It discusses the need for an educational paradigm shift, the promise of adaptive learning and what it means to higher education, and identifies key questions educational organizations need ask to prepare for the next generation of online education. In this bulletin, *adaptive technology* refers to technologies such as screen readers and closed captions that are designed to help physically challenged learners. *Adaptive learning systems* refer to technologies designed to adapt to the learning preferences of individual students and customize content based on those preferences.

Highlights of Technology for Adaptive Learning

The transformations occurring in online learning constitute a paradigm shift from a focus on emphasizing content delivery as the principal product of education to redefining the learning environments and opportunities that online instruction offers. Buckley discusses this in terms of “pedagogies founded on an understanding of the cognitive development of learning.”⁴ We have seen that, for the most part, “static page-turners” (educational Web sites that put static book pages online) have not enhanced the excitement or captured the imagination of the learning community. Research at the University of Central Florida demonstrates that online learning is most effective when coupled with face-to-face learning, so emphasis is now given to blended learning, where the online information is augmented by a classroom lecture.⁵ ECAR data show that hybrid (blended) courses are in use in about 40 percent of the institution surveyed, and the number of blended courses offered is increasing 10 percent annually.⁶

The *ECAR Study of Students and Information Technology, 2004: Convenience, Connection, and Control* key findings⁷ indicate that 95 percent of the students now entering college are what Marc Prensky⁸ calls “digital natives” who have grown up with technology. Most of the students clearly like using current course management technologies for the convenience of sharing material with students. The ECAR study concludes that current course management system (CMS) technologies provide convenience but can be enhanced through “exploration and integration of new capabilities and practices as they emerge from the arenas of video gaming, virtual reality, simulation, and modeling.”⁹

The key findings of an ECAR study on faculty use of course management systems¹⁰ indicate that faculty use them primarily to manage large classes, perform mundane task associated with the teaching, and improve communication with the students. The key findings also acknowledge faculty’s frustration with CMS technology as being time-consuming, inflexible, and difficult to use. The findings note that current CMS technology is at the first-generation level; the next generation of CMS needs to “become more sophisticated and flexible—particularly with regard to content management.”

To improve current state-of-art systems and to increase effectiveness of online education, the focus is now on adaptive learning systems—systems that can adapt the content to match the learning preference of individual learners. Adaptive learning systems demand a new perspective on learning from faculty, administrators, and students. They take pedagogy out of the realm in which the CMS operates (managing course assets) and into the realm of providing an instructional framework for faculty and effective learning for students.

The Need for a Paradigm Shift

We must think differently to fully leverage the online learning medium, which emphasizes enabling students’ personal learning strategies coupled with expert guidance from instructors. Unless we rethink how online learning can use technology to enable various pedagogical learning strategies for individual learners, it his highly

unlikely that online education will be deemed more effective than simple correspondence courses or static (and limited) delivery of classroom materials online.

Imagine technologies where learners could take full advantage of their preferred style of interaction to reach a predefined competency level and then engage in a deeper discussion with their instructors and tap their insight. The desirable features of such an adaptive learning system would include

- a pedagogical framework for supporting flexible instructional variations;
- support to provide instructional pathways that can accommodate learning styles and learning strategies;
- an ability to provide intelligent and continuous anytime, anyplace feedback to students to answer their questions and reduce the load on faculty;
- a system that can continuously monitor educational progress, generate reports, and allow faculty to provide guidance more effectively; and
- integration of interactivity, multimedia, and learning strategies in the context of the learning pedagogy.

It is important to note that the first generation of course management systems has accomplished a major milestone by providing convenience to both faculty and students for teaching and learning. The penetration of CMS into the fabric of higher education provides a necessary first step toward integration of the more advanced adaptive learning systems expected to improve instructional support and learning strategies.

The Promise of Adaptive Learning

The genesis of adaptive learning can be attributed to the development of formal theories of knowledge representation and the connectionist and symbolic approaches to learning. While the connectionist model tried to mimic the artificial model of the brain that represented the neurons by a set of simple interconnected processing elements called artificial neural networks (ANN),¹¹ the symbolic representation model created a set of knowledge-based expert rules to mimic the behavior of experts. These symbolic representations were popularly known as artificial intelligence (AI) systems.¹² These two models still dominated the debate of systems that can be trained (specifically, systems that can “learn”), require human intelligence, and go beyond the tactile and physical capacity of human beings, such as robotics, adaptive controls, machine learning, computer vision, knowledge agents, and other similar applications.

Adaptive learning systems provide the promise of improved pedagogical integration of technology in education because they facilitate

- formal representation of the knowledge domain for assembly of knowledge objects to encourage a particular educational trajectory;
- inclusion of various learning styles and strategies for the inference of learners’ preferences;

- performance evaluation mechanisms for continuous assessment of achievement of learning goals;
- a framework to provide intelligent feedback on the learning performance; and
- optimization of individual learning performance.

Adaptive learning systems promise the successful implementation of a pedagogical framework necessary to accommodate learning styles and strategies, multimedia presentations to enhance learning in the context of learning pedagogy, and continuous feedback provided by an intelligent engine to match the learning preference of individual learner.

Genesis, Definition, and Models: Adaptive Learning Systems

Adaptive learning systems originate from the substantial contributions made in the area of AI, adaptive controls, and optimizations research, where they are generally referred to as technological systems that have ability to learn and adapt based on received input signals. Generically, educational adaptive learning systems organize content based on individual learners' learning preferences in order to maximize learning performance with continuous intelligent feedback.

The first task for adaptive learning systems is to allow for various ways to organize content, offering learners different contexts and perspectives. The second task is to identify the way a learner prefers to learn by conducting diagnostic assessment of the learning preference. The third task is to use assessment results to provide continuous intelligent feedback that motivates and provides guidance to overcome concept deficiencies and helps maximizing learning performance.

Figure 1 illustrates the four iterative processes of the adaptive learning cycle that rapidly converge to tailor the learning style to individual students.

Figure 1. Proposed Adaptive Learning Cycle

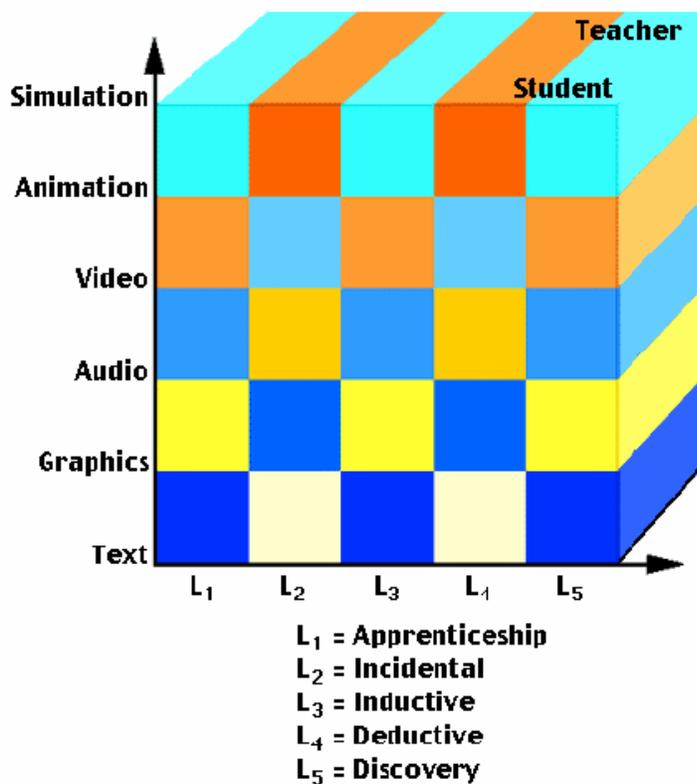


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Research by cognitive psychologists¹³ indicates that the differences in learning styles originate from the different learning strategies learners develop based on their previous learning experiences. These references in the learning strategies are related to the learning pedagogy, such as apprenticeship (learning through mentor-student interaction); incidental (learning through case study); inductive (learning through example); deductive (learning through application); and discovery (learning through experimentation).

The learning cube pedagogical model in Figure 2 provides a multidimensional framework to organize learning objects developed in text, graphics, audio, video, animations, and simulation conforming to the pedagogy of the five learning model pathways: apprenticeship, incidental, inductive, deductive, and discovery. The third axis of the cube indicated increased interactivity between student and teachers. Details of this pedagogical framework are presented elsewhere.¹⁴

Figure 2. The Learning Cube Pedagogical Framework



Content is presented to students based on the learning strategy of preference. For example, in the incidental learning strategy, learning happens primarily within a context of case studies. Content provided by the expert is sequenced in ways that explain the events involved in the case study. For students who like to learn this way, the content makes sense. For students who prefer to learn inductively, deductively, or through discovery, content is sequenced in ways that best facilitate these styles of learning. These learning strategies allow students to pursue the study of difficult subjects within the pedagogical environment that works best for them.

To assist students in finding out which strategy works best for them, the strategy is identified by an inference engine that uses diagnostic tests for making the assessment. The methodology involves using the assessment to measure performance in real time and provides continuous intelligent feedback necessary for online learning assistance. Diagnostic quizzes are embedded within each concept to assess the level of mastery that a learner has achieved. Based on students' results, an accelerated revision path with intelligent suggestions may be provided to each learner.

As illustrated in Figure 1, a learner circles through this powerful learning and revision cycle until the desired level of mastery is achieved. The adaptive learning systems

- provide instructional support to faculty to create multiple teaching pathways;

- deliver content with different learning pathways and reduce the dependency on “sage-on-the-stage” faculty lectures;
- improve student learning by customizing learning strategies;
- increase cognitive opportunity for students to learn difficult concepts by providing multiple perspectives on the concept;
- provide continuous feedback to students, allowing faculty to act as “guides on the side”; and
- monitor students’ learning progress and provide remedial content.

Adaptive learning systems thus support instructional learning styles,¹⁵ pedagogically driven instructional design, the pedagogical effectiveness of online education, and learning technology standards, such as those of the Sharable Content Object Reference Model (SCORM).¹⁶

What It Means to Higher Education

Higher education is ready to improve on the current model of online learning, and integrating adaptive learning systems into online instruction can significantly enhance both the effectiveness and efficiency of the online education experience. Adaptive learning systems will help influence:

- The blending of adaptive educational courses with expert input from professors to effect a paradigm shift from “sage on the stage” to “guide on the side.” The systems take full advantage of the pedagogical choices that an adaptive learning environment can offer, providing instructional support for faculty and a rich educational experience for students.
- The key findings of 2004 ECAR study, *Information Technology Funding in Higher Education*,¹⁷ indicate that higher education institutions need to find ways to do more with less, since IT funding is predicted to remain flat in the coming years. Adaptive learning systems might provide some financial relief across the spectrum of higher education funding, since faculty can manage larger numbers of students per course by taking advantage of the real-time assistance provided by adaptive feedback to students. Adaptive learning systems should stretch the IT dollars more effectively throughout the academic enterprise.
- While course management systems continue to provide ease of access and convenience of sharing data, adaptive learning systems that provide learning opportunities tailored to the student’s preferences; real-time, continuous feedback; enhanced assessment tools; and rich interactive and multimedia experiences for students are evolving as the next generation of educational technology.
- Technologies that bring adaptive learning systems to higher education will support alignment of IT with the organization-wide priorities of adaptive

institutions that are addressing issues of competition, financial pressures, and unpredictable threats. In specific, these technologies can create flexibility in budget processes related to faculty course load and IT infrastructure in support of the academic mission.¹⁸

Key Questions to Ask

- How can the pedagogical flexibility offered by adaptive learning systems be used effectively by our faculty?
- What kinds of training in the principles of learning pedagogy will faculty and students need to best leverage adaptive learning systems?
- What factors might impede a paradigm shift from the “sage on the stage” to the “guide on the side” mode of teaching?
- In what ways can we accommodate the individual learning preferences of the “digital natives” entering higher educational institutions today?
- What objective criteria can be used to assess the pedagogical effectiveness of online learning?
- Is our institutional infrastructure ready for the delivery of adaptive learning systems for online and blended learning?

Where to Learn More

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