

Advances in Computer-Supported Learning

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features compared. Finally, the current trends of LMS are discussed, and goals for further development are offered. A better understanding of LMS, its role in the new paradigm, and the areas where it needs to improve and continue to grow are essential to improving the effectiveness of education in the information age.

Chapter IV

Learning Management Systems: An Overview and Roadmap of the Systemic Application of Computers to Education

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Abstract

This chapter discusses learning management systems (LMS) as a technology necessary for supporting the educational needs of the information age. It defines LMS and argues that the move from the mechanistic, sorting-oriented paradigm of the industrial age to the customized, learning-oriented paradigm of the information age requires the application of LMSs to succeed. The history of LMS is presented and the definition further clarified by comparing and contrasting LMS with course management systems (CMS), learning content management systems (LCMS) and learning objects. Several major K-12 LMSs are presented, evaluated, and their

Introduction

The potential impact of computers on learning has been recognized since well before the widespread adoption of the technology itself. With a history dating back to the 1950s, computers have been used to assist with or even directly provide instruction to learners (Reiser, 1987). Learning management system (LMS) is a relatively recently coined term that refers to computer systems that incorporate providing instruction, tracking achievement, and managing resources for individual students and an organization as a whole. This chapter defines LMS, discusses the pressing need for LMS technology in the emerging knowledge-based paradigm of education, and examines the history of LMS and how it has developed from, and differs from, past computer learning technologies. LMS is then compared to other computer learning technologies and related concepts, after which four popular K-12 LMS products are described and evaluated. The chapter concludes with a discussion of the current state of LMS, what trends exist in the further development of LMS, and what needs LMS must meet in order to satisfy the requirements of the information-age paradigm of education.

Definition of LMS

Learning management system (LMS) is a generic term often used to describe a number of different types of computerized training and instructional systems. Essentially, an LMS is an infrastructure that supports the delivery and management of instructional content, the identification and assessment of individual and organizational learning goals, and the management of the progression toward meeting those goals, while providing data for the supervision of the organization as a whole (Szabo & Flesher, 2002). To differentiate LMS from the sea of acronym-driven computer learning technologies in the literature, it is important to understand the systemic scope of LMS. An LMS, as Gilhooly (2001) states, “goes beyond basic content delivery to offer course administration, registration, tracking, reporting and skills gap analysis” (p. 52). General characteristics include the following:

- instructional objectives are specified with individual lessons;
- lessons are integrated into the standardized curriculum;
- courseware extends several grade levels in a consistent manner;
- a management system collects and records the results of student performance; and
- lessons are provided based on individual students' learning progress. (Bailey, 1993)

Need for LMS

There have been a substantial number of publications discussing the shift of society from the Industrial Age into what many call the Information Age (Reigeluth, 1994; Senge, Cambron-McCabe, Lucas, Smith, Dutton, & Kleiner, 2000; Toffler, 1984). In order for our schools to meet the needs of today's learners, the way in which the schools function must also change dramatically and systemically to focus on individual learners' needs (Reigeluth, 1994; Reigeluth & Garfinkle, 1994; Senge et al., 2000).

The current educational system was built to fit the image of the industrial-age society, in which learning is highly compartmentalized into subject areas and students are "treated as if they are all the same and are all expected to do the same things at the same time" (Reigeluth, 1994, p. 204). Furthermore, much of the onus for learning is laid at the feet of teachers rather than the students themselves, and students do not take an active role in either their own learning or the school community as a whole. The current industrial model of education places an emphasis on sorting students rather than developing their knowledge. A fixed amount of content is presented in a fixed amount of time, and students must move on, whether they have learned it or not. Students are divided into grade levels with classes in which they learn the same things at the same time. This forces "achievement to vary among students, with the consequence that the low-achieving ones gradually accumulate deficits in learning that handicap them in their future learning endeavors" (Reigeluth, 1997, p. 204), while high-achieving students are held back and lose interest. The system is not designed to promote student learning; it is designed to select students. In the industrial age, it was important to separate the laborers from the managers, and educating the common laborers was not economical and, indeed, was not desired, for they would not be content doing the repetitious and dull tasks that their jobs at the assembly lines would require (Joseph & Reigeluth, 2002).

However, today the mechanistic, unthinking jobs of the assembly line have largely disappeared, and employers are now looking more and more for problem-

solving employees with initiative and a variety of skills to work effectively as a part of a team. These requirements reflect a need, in the information age, for expanded mental capabilities, which greatly increases the importance of student learning. The focus of education must shift from student sorting to student learning, and therefore, certain changes are required to truly help students learn. Since it is known that children learn at different rates and have different learning needs, even from the first day of class, it does not make sense to hold time constant and thereby force achievement to vary. Apart from not meeting the needs of society at large, it is an inhumane treatment of the children to not focus on helping all children to reach their potential. The alternative to holding time constant is to hold achievement constant at a mastery level, and allow children to take as much time as needed to reach that level. This requires the educational system to move from a process of standardization that results in high failure rates to a completely new paradigm that supports customization in order to meet all learners' needs.

This new paradigm for information-age-appropriate education will require significant changes in the use of time, talent, and technology (Schlechty, 1991). The changes in use of time entail not only allowing each student as much time as needed to achieve mastery, but also allowing each student to move on as soon as he or she reaches a mastery level. This means that the pace of instruction will be customized to help meet each student's needs.

Schlechty (1991) also argues that the use of talent will need to be altered. Talent refers to the roles that both students and teachers play. The role of teachers will change substantially as instruction moves to a more learner-centered approach (McCombs & Whisler, 1997). Teachers will become facilitators of knowledge acquisition by acting as guides, coaches, and motivators for students. No longer will the teacher be the primary source of knowledge, a talking head, but instead the teacher will help each student to find appropriate materials for acquiring the desired knowledge. This shift in roles will also place new demands on the student. Students will be required to be active learners, assuming the responsibility to take initiative and be more self-directed as they gain knowledge.

The third shift that Schlechty (1991) argues will be necessary in the new paradigm of education involves the use of technology. First, with learner-centered, custom-paced instruction, technology is needed to track what each learner has mastered. This will allow teachers to easily keep records of each student's progress and thereby provide appropriate guidance to each student. Second, decisions about what to learn next (i.e., the sequencing of instruction) for each student will also be important, and technology will need to play a central role in helping student and teacher decide what should be learned next. Third, as teachers move from being the sole source of instruction to being guides or coaches, technology will be needed to help instruct the students by providing

content, often in more interactive ways than have traditionally been used. Simulations and instructional games can provide interactive content, give immediate feedback, diagnose student needs, and provide effective remediation. Fourth, technology will also be needed to help in the assessment of student knowledge to certify student mastery and store examples of student work that represent their attainments (e.g., portfolios). Finally, technology will need to provide a systemic integration of all of these features.

In essence, an information-age, learner-centered paradigm of education cannot be effectively implemented without technology, and by the same token, technology cannot approach its potential contribution to education and learning without a learner-centered paradigm of education.

Fortunately, computing is becoming more ubiquitous every day, and a major part of the information-age classroom will be the use of advanced technology to meet the five needs just listed. Instructional technology has shown promising results in evaluation studies conducted during the 1960s to 1980s, and technology is widely used in schools these days. In envisioning the information-age school, "technology will play central roles in teaching, assessment, and keeping track of learner progress..." (Reigeluth & Garfinkle, 1994). LMSs promise an integrated tool for serving the five major functions that are needed for technology in information-age schools.

History of LMS

LMS has evolved through a history of various applications of computer technology to instruction. These applications have been described with various terms, many of them generic. Computer-based instruction (CBI), computer-assisted instruction (CAI), and computer-assisted learning (CAL) are all generic terms that have been used to describe different applications of computers to instruction. While there are not specific definitions for these terms, Parr and Fung report that generally, CAI is typically used to describe drill-and-practice programs, CAL includes more sophisticated tutorial instruction, and CBI places more emphasis on individualized instruction (Parr & Fung, 2001). More differentiated from these other terms are integrated learning system (ILS) and computer-mediated instruction (CMI) which include such additional functionality as a management and tracking system on top of the instructional content, integration across the system, and greater focus on personalized instruction (Bailey, 1993; Becker, 1993; Brush, Armstrong, Barbrow, & Ulintz, 1999; Szabo & Flesher, 2002).

In the early 1980s, many classroom teachers and administrators turned away from ILSs because they appeared to be the same old products in new packaging. Most of these educators were primarily skeptical about how individualized instruction and computer-assisted instruction came and went with other educational trends of the 1960s and 1970s. But as more sophisticated ILS software began to address problems associated with individualizing instruction, it began to show greater potential to improve learning and teaching, and it evolved into a more holistic learning and data management system. Now, LMS takes these additional components even further in helping to "manage the entire instructional program and learning process" of an organization (Szabo & Flesher, 2002). Further, LMS is systemic in nature, covering both learning and e-learning programs and processes. It is this systemic nature that differentiates LMS from much of the other educational software available, in that it is neither simply a collection of instructional software nor only a student assessment tracking platform, but is instead truly systemic in addressing all aspects of the instructional process.

LMS' Relation to Course and Content Management Systems and to Learning Objects

While we have addressed the definition of LMS and further detailed this definition by looking at the history of LMS and its relation to past computer learning technologies, it is important to also discuss the role of LMS amongst other related advancements in computer learning technologies. These include course management system (CMS), learning content management system (LCMS), and learning object (LO). While LMS is often used synonymously with CMS and LCMS and is conceptually seen as having equivalent goals as LO, LMS is again differentiated by its scope, and this section explores how LMS is related and impacted by these technologies due to its systemic incorporation of them.

Course Management System

One technology that is often confused with LMS is CMS. The systemic nature of LMS previously discussed differentiates LMS from CMS. A CMS is a tool that focuses on the management of one or more courses, typically by an instructor,

and is usually used for distance education or hybrid (both face-to-face and distance) courses. As defined by the EduTools' Web site, a CMS excludes:

Single function software like stand-alone assessment tools, synchronous tools or authoring packages that do not also have many other features or act as part of a larger suite that delivers online education courses, and course content materials and course content bundled with its own online delivery system. (Leslie, 2003²)

A CMS is a tool that just helps an instructor to manage individual courses, rather than also providing a system-wide tool. Its function is defined as: "it provides an instructor with a set of tools and a framework that allows the relatively easy creation of online course content and the subsequent teaching and management of that course including various interactions with students taking the course" (EDUCAUSE Evolving Technologies Committee, 2003, p. 1). Examples of a CMS include Blackboard, WebCT, Angel, and Oncourse.

Learning Content Management System

LCMS is often used either synonymously with LMS or touted as a newer version of LMS. However, the focus on content is the key to understanding the difference between these two technologies and seeing how they relate. Oakes (2002) reports that the IDC defines LCMS as a system that is "used to create, store, assemble and deliver personalized e-learning content in the form of learning objects" (p. 73). So, the focus with LCMS is on content: "it tackles the challenges of creating, reusing, managing, and delivering content" (Oakes, 2002, p. 74). While LCMS focuses on content, an LMS is "learner and organization focused: It's concerned with the logistics of managing learners, learning activities, and the competency mapping of an organization" (Oakes, 2002, p. 74). Connolly (2001) echoes this, stating that while LMS and LCMS complement each other, the "LMS provides the rules and the LCMS provides the content" (p. 58).

Learning Object

Learning object has become a highly visible buzz-word in education recently and is taking its place as the favored technology for the future, based on its promise for reusability (ability for instruction to be reused in multiple contexts), generativity (the ability to generate instruction), adaptability (ability to be adapted to individual learners), and scalability (ability to be extended to both larger and smaller

audiences without a substantial increase in cost) (Gibbons, Nelson, & Richards, 2002; Hodgins, 2002; Wiley, 2002).

While learning object is fairly consistent in its promise of instructional design that reduces costs and produces instruction that is adaptable to individual learners and contexts, the actual definition of learning object remains unclear. Learning object has been used to describe everything from a textbook to a computer image to an instructional simulation or video game. Furthermore, terms other than learning object are sometimes used to describe what appear to be learning objects, such as MERLOT's use of "online learning materials," or Merrill's use of "knowledge objects" (MERLOT, 2005; Merrill, 2002). Parrish (2004) notes that the Institute of Electrical and Electronics Engineers (IEEE) provided the vague definition of a learning object as "any entity, digital or nondigital, that may be used for learning, education, or training" (p. 52). Wiley (2002) notes how this definition does not exclude anything related to instruction of any type. He therefore proposes his own definition of a learning object as "any digital resource that can be reused to support learning" (2002, p. 3).

This definition seems to be more on par with the general definition of a learning object as a reusable digital artifact that can be used in learning. However, Parrish (2004) argues that this definition does not eliminate software tools a student might use, such as a calculator or word-processing program. He instead argues for defining learning object in terms of its use or function: "instructional content becomes a learning object when it is used as a learning object" (p. 52).

While Parrish's arguments have some merit, and it is certainly unclear whether Wiley intends to include instructional tools in his definition as well as instructional content, it seems that Parrish's approach might result in more confusion in the long run among those unfamiliar with object-oriented concepts. However, Wiley's use of the term "resource" to describe the object itself could cause some confusion. The key elements of learning objects that lie behind much of the discussion would seem to be the ideas of learning and reusable artifacts. These artifacts would not typically include tools; therefore, Wiley's definition would be more precise if it referred to digital "media" rather than digital "resource." This clarification seems to capture the key concepts and the general understanding of learning objects and their benefits without requiring a more expert understanding of the object-oriented design process that Parrish's definition calls for. Furthermore, Parrish (2004) admits that, while the concept of breaking instructional systems into smaller reusable objects and methods is related to learning object creation, he points out that learning is different than computer programming, and the concepts of object-oriented programming are not a perfect fit to the instructional design of learning objects.

It should be clear that learning object, while related to LMS, certainly exists at a much narrower scope than LMS. While the key component of LMS is its

systemic nature, a key feature of learning object is its modularity, discreteness, and reusable nature.

The Interconnectedness of Learning Object, CMS, LCMS, LMS, and Associated Challenges

This section has shown the close relationship between learning object, CMS, LCMS, and LMS. The role of LMS as a systemic manager of the included technologies places a focus on scope when seeking to understand the differences among these kinds of tools. Furthermore, just as the LMS encompasses the other technologies, learning objects by definition exist as the smallest discrete components of all of these technologies; they make up the reusable instructional content that is managed by an LCMS and are plugged into the courses managed by a CMS, both of which are pieces of the larger, systemic LMS. To be reusable, learning objects by nature need to be distinct. Therefore, to better understand how all of these technologies tie together to form an LMS, it is important to also examine the challenges that exist with the creation, sharing, and use of learning objects.

There are several current challenges to the implementation of learning objects. Foremost among these problems is the need for standards to allow learning objects to be reusable and searchable across different educational systems. A key component in this search for standards is meta-data, which is used to describe the learning object and make it accessible. Without a standard for meta-data, even if a learning object is made to be reusable, it is unlikely to be reused, simply because access to it is severely limited by the lack of meta-data. Unfortunately, there are many current standards being applied to the creation of learning objects, including LOM, CanCore, and SCORM. The lack of standards for learning objects causes a trickle down effect which negatively impacts LMSs.

Just as there are many standards for learning objects, there are also several standards "for evaluating interoperability between LMSs and content" (Connolly, 2001, p. 57), mainly SCORM and the Aviation Industry CBT Committee (AICC) standard. Furthermore, there is also no agreement as to exactly what LMSs must do to be compliant with the standards that exist, as each of these standards has multiple levels of compliance (Alexander, 2001). Ultimately, confusion aside, one large problem with applying standards is the inherent cost. Much of the content being used by LMSs was developed well before standards existed or have never had standards applied. Furthermore, content providers have their own proprietary software development tools that do not support standards, so the cost of converting old content to meet standards, and acquiring industry

development tools which support compliance with standards, can be prohibitive. Finally, there is the issue of what kind of instruction is promoted by learning objects and LCMS. Parrish (2004) cites Wilson's 2001 discussion of the spectrum in distance education where one trend focuses on automation, standards, and control (the old practice of "drill and kill" software), while the other end of the spectrum points toward open systems and learner-centered approaches. If a strong reason for the use of computers in the classroom is to use the processing and tracking power they offer in order to help customize learning, then perhaps the learning objects being created should be modifiable by students or their instructors in order to help establish learning environments that allow for exploration and the building of knowledge, as opposed to the limited interactivity of assessing the ability to regurgitate static facts (Parrish, 2004).

Much of the learning software used today promises personalization but does not deliver outside of the barest sense of students being able to move through static instruction at their own pace, while the system assesses their progress. LMSs today are based somewhat on the concept of learning objects, in that they present digital instruction that can be tailored to state and federal educational standards and therefore can be sold to schools across the world. The reusable nature of these learning objects shows the successful promise of learning objects while at the same time going against the notion of an open environment by charging schools for access to the objects. Many of the current LMSs available to schools in the United States are offered by companies with a long history of creating digital instructional modules for their customers. These modules are essentially composed of the learning objects that the LMSs are reusing. The LMS then provides additional features, to support students' learning such as assessing the student's performance and customizing the sequencing of additional objects. While LMS and its various components face challenges, it also holds a great deal of promise, and some applications offer features that are well-suited for a learning-focused paradigm of education. A better understanding of the nature of existing LMSs can be reached by examining the various features currently offered by the major K-12 LMS products available in the United States, as well as looking at existing research into their application.

Comparison and Evaluation of Existing LMSs

This section presents and compares the major features of a number of LMSs available today for K-12 schools, and it provides a general overview of the evaluative research that has been conducted on those LMSs. Since these LMSs

are highly complex systems, the number of features they possess is so large as to be unmanageable in a review such as this. Therefore, a conceptual framework of major features is presented to facilitate this description and comparison of features. Table 1 shows the features identified from our analysis of LMSs that seem to be the most important for understanding them.

It is helpful to note the features that are particularly well-suited to meeting the needs of the information age, for some of the LMSs were developed to meet the needs of the sorting-focused paradigm of education. However, it is likely that these products will continue to develop and move toward providing true, systemic, integrated, learner-centered features such as: customizable, unique instructional content, individual pacing, assessment of individual learning gaps, addressing those gaps, and further involving students and their parents in learning.

The LMSs examined are some of the largest LMSs available in the United States: PLATO, Pearson Digital Learning, SkillsTutor, and Co-nect. The sheer number of educational programs under the umbrella of a larger product system makes the comprehension of what each product offers daunting. Pack (2002) states that one of the first hurdles to implementing a new program is "sifting through the multitude of proffered solutions" (p. 23). He references e-learning analyst Bryan Chapman, who states that, at that time, there were more than 650 vendors of e-learning products. While the trend has been the merger and absorption of products into the larger LMS companies, it can still be very confusing trying to sort out what each product actually does. Pack (2002) quotes Healy, a research analyst for education and training, who describes the market: "It's just a big mess... There are way too many platforms and solutions right now. There's a lot of confusion on the buyer's side" (p. 23). Further complicating this is the focus on industry buzz-words and the use of marketing language common in the literature of these companies, which makes it difficult to determine if the products truly offer, or to what degree they offer, certain features, such as customizable instruction. This section reports the results of a determined attempt to sift through the morass of information and present a comparison of several of the major current LMSs for K-12 schools.

PLATO

PLATO is currently one of the largest LMSs used in K-12 schools and governmental institutions in the United States. The LMS PLATO was initially designed as a CMI system for use with PLATO, which was at the time a mainframe system completely devoted to the delivery of instruction and training. This system was designed to work with other curricula and to manage other courseware in the corporation. Another CMI system was custom-developed for

Table 1. Major features of LMS

(grayed features support information-age needs)		Features
Instructional Method	Standard features	Content presentation Curriculum standards Direct instruction Bilingual Self-paced learning Project-based work Authentic real-world problems Individualized instruction Adaptive sequencing Adaptive lesson plans Customizable instructional content Presentation of lessons
	Teacher customizability	Online message center Online discussion board Project-based work Activities homework with parent involvement Community relations and support Online lesson plan management for teachers
Data management	Outside school	Attendance Health information Parent/guardian information Enrollment Class schedule Record of attainments mastered Mastery progress
	Data management	Post test / Pre test Formative tests Practice tests Diagnostic tests Mastery level tests
Assessment	Assessment	Summative test report to teachers/ parents Formative test report to teachers/ parents Student information report to teachers/ parents
	Assessment	Record of attainments report to teachers/ parents Mastery progress report to teachers/ parents Customizable reporting for teachers
Reporting	Reporting	
	Reporting	

the University of Illinois PLATO system, which later became the original system of CDC PLATO (Szabo & Flesher, 2002).

The PLATO system provides a wide variety of instructional programs, as well as district software and assessment and reporting tools. The products are organized into three categories: accountability solutions, assessment solutions, and instructional solutions (PLATO, Inc., 2005).

PLATO's accountability solutions include data warehousing and synchronization tools, standards and curriculum integration tools, and a collection of communication tools and resources called the PLATO Network. Together, these tools allow local standards to be defined; assessments to be associated with specific standards; student, school, district, and professional data to be collected, stored, and managed; and communication to be promoted among members of the learning community (including students and their families) through the sharing of information and resources.

PLATO's assessment solutions provide a wide variety of testing products, many of which are tied directly to PLATO instructional products. Students may take practice tests, have their learning assessed and learning gaps identified, and either have a PLATO curriculum path automatically generated or have a customized path developed for them by their teacher. PLATO also provides teachers a way to create their own assessments in addition to providing practice for such tests as the National Writing Test, the GED, and the Pre Professional Skills Test, as well as a practice test for helping paraprofessionals meet the testing requirements of the No Child Left Behind Act of 2002.

The instructional programs are for elementary, secondary, and post-secondary grade levels. Subjects include reading, writing, mathematics, science, social studies, and life and career skills, as well as interdisciplinary and ESL/ELL curriculum in Spanish. Plato focuses on providing self-paced, individualized learning environments with tutorials and practice opportunities that are highly integrated with curriculum standards. With a 30-year heritage of research and development, PLATO claims that it strives to constantly evolve and grow to realize learner-centered, information-age education (Foshay, 1998). In summary, Table 2 shows the features that PLATO seems to offer, though we advise that these ratings be interpreted with caution, and many features are a matter of degree rather than yes-no.

PLATO has a large body of evaluation studies, mostly conducted by PLATO's own evaluators and evaluation consultants from research laboratories. Foshay conducted a meta-analysis of 13 PLATO evaluation research studies conducted from 1993 to 2001. The study's target populations included urban, suburban and rural, underachieving, low-income populations in elementary, secondary, and post-secondary education settings. The analysis showed improvements up to 60% on achievement of standards. The pass rates on state exit exams ranged up to 85% in English and 100% in math.

Kulik (2003) also conducted a meta-analysis on 20 studies of PLATO based on Foshay's analysis conducted in 2002. The evidence reviewed in this report provides support for the effectiveness of PLATO learning products, both as supplementary and as the only instruction compared to low-tech, traditional instruction alone. However, there were eight studies using a control group which

Kulik identified as providing the most reliable data. In these studies, which used an experimental group receiving solely PLATO instruction and a control group receiving only conventional instruction, the average effect size Kulik found was 0.43, which suggests positive effects of PLATO. However, as Foshay (2002) points out, the relationships between achievement and time on task with PLATO are complex, and the effects of PLATO were never measured in isolation from

Table 2. Major features of PLATO

(grayed features support information-age needs)		PLATO
Instructional Method	Standard features	✓
	Teacher customiz-	✓
	ability	✓
	Outside school	✓
	Attendance	✓
	Health information	✓
	Parent/guardian information	✓
	Enrollment	✓
	Class schedule	✓
	Record of attainments mastered	✓
Data management	Mastery progress	✓
	Post test / Pre test	✓
	Formative tests	✓
	Practice tests	✓
	Diagnostic tests	✓
	Mastery level tests	✓
	Summative test report to teachers/parents	✓
	Formative test report to teachers/parents	✓
	Student information report to teachers/parents	✓
	Report of attainments report to teachers/parents	✓
Assessment	Mastery progress report to teachers/parents	✓
	Summative test report to teachers/parents	✓
	Formative test report to teachers/parents	✓
	Student information report to teachers/parents	✓
	Report of attainments report to teachers/parents	✓
	Mastery progress report to teachers/parents	✓
	Customizable reporting for teachers	✓
	Online message center	✓
	Offline discussion board	✓
	Project-based work	✓
Activities (e.g. work, writing, play, etc.)	✓	
Community relations and support	✓	
Online lesson plan management for teachers	✓	

