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A comparison of learning management systems in a school district: searching for the ideal personalized integrated educational system (PIES)

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This study explored the use of several learning management systems (LMS), their benefits, and their limitations in relation to the desired characteristics of an ideal Personalized Integrated Educational System (PIES) for the information age. A qualitative research design was used. The participants of the study were teachers, administrators, and technology coordinators in a small suburban school district. The data were collected through interviews and were subjected to content analysis. The findings of the study indicated that each of the LMSs investigated in this study still has some significant limitations, for none of them provides all the information-age functions of PIES, and what an ideal PIES should possess as information-age functions can be categorized under students' learning, assessment and system-related preferences.

Keywords: learning management systems; personalized integrated educational system; information-age features; learner-centered paradigm; customized learning

Introduction

As our societies evolve from the industrial age to the information age (Toffler, 1980), we are finding that our current paradigm of education, the factory model of schools, is increasingly unable to meet our educational needs, just as the agrarian-age paradigm, the one-room schoolhouse, was unable to meet the new educational needs of the industrial age. The distinctive characteristics of an information society offer guidance as to the characteristics our new paradigm of education should have. They include customization (versus standardization), diversity (versus uniformity), initiative (versus compliance), self-direction (versus control from "above"), and collaborative relationships (versus adversarial relationships) (Reigeluth & Garfinkle, 1994). Based on these characteristics, transformation of education in line with the information society's needs and creating a new paradigm of education that can redesign itself seem to be unavoidable (Sezal, 2005).

The need for this new paradigm of education, often called the learner-centered paradigm (McCombs & Whisler, 1997), has been emphasized by many educators (see

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e.g. Huba & Freed, 2000; Sezal, 2005; Watson, Lee & Reigeluth, 2007; Weimer, 2002). According to Huba and Freed (2000), in the learner-centered paradigm, knowledge is constructed by students through gathering and synthesizing information to solve real-world problems, whereas in the factory model, or teacher-centered paradigm, knowledge is transmitted from the instructor to students outside the context in which it will be used. In the learner-centered paradigm, students are actively involved in the learning process, and the instructor and learners evaluate learning together (Huba & Freed, 2000). Students are allowed as much time as they need to achieve mastery (Schlechty, 1991), and the course is structured in a way for students to master learning objectives rather than being forced to move on to the next topic even if they have not yet mastered skills and understandings for the current topic (Bloom, 1968). Instructors are facilitators of the knowledge acquisition process by acting as guides, coaches, and motivators as students become more active in their learning process (McCombs & Whisler, 1997).

Weimer (2002) discusses the changes the learner-centered paradigm will bring. If the instructor gives students some control over the learning processes, the students are motivated to work harder, and they come to develop initiative and self-direction. Power sharing with students also benefits teachers because they no longer struggle with passive, uninterested, and disconnected students. Weimer (2002) also describes instructors teaching less content in the learner-centered paradigm, and largely focusing on development of learning skills and learners' self-awareness, which are very important to develop students' self reflection and critical thinking skills.

Watson, Lee, and Reigeluth (2007) indicate that "the 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" (p. 70). Similarly, Reigeluth et al. (2008) emphasize that, "in order to provide a quantum improvement in student learning, powerful technological tools are needed in this new paradigm" (p. 32). According to Watson and Watson (2007), Schlechty (1991) specifically addresses the role of technology by saying "it will be needed to track each student's progress toward mastery, assess their learning, help teachers understand what sort of guidance is needed, provide appropriately sequenced instruction, store evidence of attainments and systemically integrate each of these functions" (p. 31). Through such roles, technology enables customized learning based on learners' characteristics. Watson and Watson (2007) indicated that this description is closely aligned to the functions that technology needs to serve in support of the learner-centered paradigm of education (keeping records of mastery, creating personal learning plans, offering customized instruction, assessing individual mastery, communicating, administering general data, managing school personnel information, and administering the use of the learning management systems [LMS]). Similarly, Taylor (2004) points out that some of the areas where technology can offer significant contributions to schools and classrooms include customizing assessments, analyzing student progress, evaluating student performance, tracking academic achievement, and identifying areas for additional scaffolding or assistance.

Among the available technologies for instruction and learning, LMSs appear to be the most promising tool to facilitate learner-centered instruction in information-age schools, though most of the current LMSs have been designed to support the industrial-age paradigm of education. Szabo & Flesher (2002) points out that "learning management systems are computer-based database and presentation

systems which manage the entire instructional program and learning progress of employees with respect to the competencies specified by the goals and objectives of an organization'' (p. 1). Similarly, Reigeluth et al. (2008) maintain that LMSs could 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 toward mastery of required attainments and deep knowledge of all standard subjects and skills'' (p. 38). Most LMSs include some or all of the following core components: course management tools (syllabus, calendar, drop boxes, announcements), content tools (content pages, quizzes, assessments), and communication tools (asynchronous e-mail, discussion forums, chat), all of which allow instructors to provide content and learning activities, test learning, receive assignments, and conduct discussions and other course-related activities in a principally asynchronous online environment (Simonson, Smaldino, Albright & Zvacek, 2006). However, many of these features are designed to support the current paradigm of education.

Reigeluth et al. (2008) specifically propose a set of information-age functions for the learner-centered paradigm to facilitate a quantum improvement in student learning. These essential functions include four major roles for an educational system to support student learning (*recordkeeping, planning, instruction, and assessment*) and four secondary roles (*communication, general data administration, school personnel information, and LMS administration*). In more recent work, these authors refer to this kind of information-age system as a Personalized Integrated Educational System (PIES), to distinguish it more clearly from LMSs that do not serve all these functions. There is sometimes confusion between LMS, Virtual Learning Environment (VLE), and Managed Learning Environment (MLE). While LMS is the more common usage in North America, VLE is more commonly used in the UK, Europe and Asia (Kats, 2010). Virtual Learning Environment is one possible component of a MLE. Managed Learning Environment refers to the ''whole range of information systems and processes of a college or university (including its VLE if it has one) that contribute directly, or indirectly, to learning and the management of that learning'' (Joint Information Systems Committee, 2012). Different organizations may have different types of MLEs because they have different educational and business needs. Following are the information-age functions that traditional LMSs or VLEs do not serve well.

Recordkeeping for student learning includes maintaining a ''standards inventory'' (a list of anything that one could choose to learn), a personal attainments inventory (a list of what each student has already learned), and a personal characteristics inventory (a list of each student's characteristics that influence how that student learns best). This first function is required in the new paradigm of education for the system to ensure that progress is continuous and personalized, and to the trio of stakeholders (students, parents, and teachers) to make good decisions about what to learn next. *Planning for student learning* includes identifying long-term goals, current options for learning next, short-term goals, projects, teams, and roles on teams, and using these to prepare each student's contract or personal learning plan. The planning tool is crucial since customizing the learning experience will not be feasible without such a tool, and the tool will enable student, teacher, and parents to collaborate for planning the student's educational development. *Instruction for student learning* offers project initiation, project support, intensive instructional support, and instructional development components. To truly support learner-centered instruction, the teacher plays the role of ''coach'' rather than doing all the

teaching. *Assessment for student learning* includes using authentic tasks, providing immediate feedback (formative evaluation), and certifying student attainments (summative evaluation), and helps teachers to develop student assessments. Assessment is integrated with instruction, and students and teacher can evaluate learning together and structure curriculum together (Allen, 2004).

Four secondary functions play an important role in facilitating students' learning, even though they are not directly related to the learning process. The *communication* function involves teacher communication and collaboration with other teachers, with students' parents, and with students. It also helps students to communicate and collaborate with each other to facilitate their learning. The *general student data administration* function provides access to such data as the student's name, address, birth date, parent information, health information, attendance, the student's mentor and other teachers, records of major life events, the school or learning community to which the student belongs, the student's home room, and community organizations with which the student is involved. The *school personnel information* function provides access to such information as a staff member's name and address, assigned students, certifications and awards, professional development plan and progress, and the teacher's physical location. The *administration* function helps change the settings of the whole system, such as restricted access to sensitive information about students (Reigeluth et al., 2008).

Vrasidas (2004) emphasizes that the needs of today's learners are not being fully met by current technological tools. Major problems with available technology are poor customizability of the system, limited interoperability with other LMSs, poor reusability, high cost, lack of pedagogical affordances, and teachers not applying pedagogical principles when they use LMSs.

The learner-centered paradigm of education requires appropriate technological tools that serve information-age functions rather than industrial-age functions (Reigeluth et al., 2008; Watson, Lee & Reigeluth, 2007; Watson & Watson, 2007). In that sense, it is essential to investigate which of the above-mentioned information-age functions are currently being served by existing LMSs, and how those functions are used in educational settings. The results will help schools interested in paradigm change to know what information-age features are offered by each LMS investigated in this study. Additionally, the findings of this study will provide insights in improving LMSs to better facilitate the learner-centered paradigm of education. The following research questions guided this study:

(1) What features of LMSs are used, and how are they used by the participants?
(2) What are the participants' opinions about benefits and limitations of the LMSs they are using?
(3) What are the participants' opinions about how well the information-age functions are served by the LMSs they are using?
(4) What are the participants' opinions about the information-age features that an ideal LMS should have?

Method

A qualitative research design was used in this study. Qualitative research is concerned mainly with "describing in detail what goes on in a particular activity or situation" (Fraenkel & Wallen, 2003, p. 431), and it is an inquiry of understanding

people's interpretations and behaviors in a complex, holistic picture in their natural setting. Qualitative research involves fieldwork, and its process is inductive in that abstractions, concepts, hypotheses, and theories are evolved from the data collected (Creswell, 1994; Merriam, 1988). The focus of qualitative research is to gain real, rich, and in-depth data. In this study, the qualitative research design enabled us to examine the LMSs used in the district's schools in regard to the experiences of the teachers, the administrators, and the technology coordinators.

This study was conducted in a small suburban school district with one early childhood center, four elementary schools (ages 7 to 10), two intermediate schools (ages 11 to 12), one middle school (ages 13 to 14), and one high school (ages 15–18). The total student enrollment was approximately 6100. The school district had 333 full-time teachers, 18 administrators, and 50 non-teaching licensed personnel (e.g. guidance counselors, librarians, curriculum directors, etc.), and had been engaged in a district-wide systemic change effort since 2001 in collaboration with a research university. The aim of the systemic change effort was to transform to the learner-centered paradigm of education. In line with its systemic change effort, the district had been using LMSs to provide some learner-centered education for several years. Therefore, the district was selected purposively as an appropriate case to examine the features, benefits, limitations, and potentials of those tools to meet the requirements of the learner-centered paradigm of education.

The participants in this study were the teachers, administrators and technology coordinators who had been using the LMSs frequently. First, the technology coordinator of the school district identified 23 teachers, two administrators and two technology coordinators who had been using the LMSs in the district. Those LMSs included Odyssey, NWEA (North West Evaluation Association), Skyward, Atlas, Plato, and PeBL. Among those, six users (two teachers, two administrators, and two technology coordinators) volunteered and participated in this study.

The data were collected in March and April 2009 through semi-structured interviews. A different semi-structured interview protocol was developed for each group – the teachers, the administrators, and the technology coordinators. In developing the interview protocols, the conceptual frameworks developed by Watson, Lee and Reigeluth (2007) and by Reigeluth et al. (2008) on the features of PIES were used. The interview protocols were reviewed by two instructional technology experts. Based on the feedback gathered from the expert reviews, the interview protocols were revised. Finally, the interview protocols consisted of nine questions with five themes for the teachers, 10 questions with five themes for the technology coordinators, and six questions with five themes for the administrators. The themes in the interview protocols were data management, instructional methods and assessment, reporting and information-age functions, respective advantages and limitations, and participants' preferences for ideal PIES features.

The interviews were conducted individually with the two teachers and two administrators. However, the two technology coordinators were interviewed together in accordance with their request, and one of the teachers was interviewed by phone based on the teacher's request. Each interview lasted about 30 to 50 min.

The data collected through the interviews were subjected to content analysis. Meaningful phenomena in the data were identified, and descriptive codes were assigned in the content analysis in accordance with the conceptual framework used in the study (from Reigeluth et al., 2008). Marshall and Rossman (1999) indicated that data analysis includes ordering, structuring, and interpreting the mass of

collected data. In line with that statement, the following steps were followed: (1) The data were coded to formally represent, classify, and organize the data. (2) The main categories and themes were extracted from the coded data in accordance with the research questions. (3) In order to rearrange the codes in a meaningful and consistent way, the coded data were organized under these themes. (4) Categories were rechecked to determine how they were linked. (5) The data were interpreted.

Having data sources from different positions (technology coordinators, administrators and teachers) helped us clarify and verify (triangulate) the findings, and also have different perspectives about the investigated issue. The coded data, extracted themes, and organization of the coded data under the related themes were checked and rechecked by the researchers to eliminate any misunderstanding.

Findings

The LMSs used in the Decatur school district were NWEA, Skyward, Odyssey, (Campus Learning version for Odyssey High School), Data Mine, PeBL, Atlas, and Plato. PeBL was used only by New Tech High School. The other LMSs were used in all schools other than New Tech High School.

Below, is a description of data collected from the participants about the first two research questions. Then the third question is addressed, followed by the fourth.

The first two research questions

(1) What features of the LMSs are used, and how are they used by the participants?
(2) What are the participants' opinions about benefits and limitations of the LMSs they are using?

The LMS features used

The findings of the interviews indicated that the LMSs available in the school district were used for instruction, data management, assessment, and communication. The benefits and limitations of the LMSs indicated by the interviewees are presented in Table 1 and discussed below.

Skyward: All participants indicated that this was a data management system and was not used for instructional purposes. It was used for keeping student data (demographic, attendance, schedule, grades, and discipline actions), scheduling, communication, and parental access. Some information could be changed by the parents as long as the district authorized them to change it. The *benefits* of the system were indicated as: it enabled monitoring of each student's schedule, keeping student data, and providing parental access to the student data. The *limitations* indicated were that the scheduling tool needed improvement, it did not communicate with other systems, it was not easy to use and was cumbersome for generating information or reports, and it did not directly relate to student learning. The other limitations indicated by four of the participants two of whom were using PeBL actively were described as follows: the tool did not allow entering eight important learning outcomes – collaboration, oral communication, written communication, critical thinking, career preparation, citizenship and ethics, curricular literacy, and

Table 1. Summary of the benefits and limitations of each LMS.

LMS	Benefits	Limitations
Skyward	*General data:* Non-instructional data (demographic, attendance, schedule, grades), with parental access. *Communication:* Parental access to student data.	Different types of learning outcomes cannot be entered. Scheduling tool was weak. Could not exchange info with other systems. Difficult to use and generate reports.
Odyssey (Compass Learning)	*Record-keeping role:* List of lessons for each Indiana standard; system could generate a variety of reports (attendance, learning) for students, teachers, and administrators. *Planning:* Activities could be assigned to either an individual or a group of students. *Instruction:* Customized pacing; interactive instruction; teachers could create lessons; lesson templates were customizable; lessons were customizable; video was available. *Interoperability:* Could exchange info with NWEA. *Maintenance:* Cost-effective to maintain. *Ease of use:* User-friendly. *Communication:* Provided online access; parents could monitor student progress.	None reported for the system itself; however, licensing to a limited number of students and staff created some accessibility problems.
NWEA	*Planning:* Required mastery-based progress; created a personal learning path in Odyssey based on test results. *Instruction:* Supported personalized learning; provided credit recovery and intervention programs; teachers could modify or create student-specific lessons; was linked with Odyssey – instruction path was created in Odyssey. *Assessment:* Assessed each student's mastery level.	(Not mentioned.)
PeBL	*Record-keeping*. Kept student grades; generated extensive reports; monitored students. *Planning:* Maintained a project library; helped students make a contract; project phases could be generated by the teachers. *Instruction:* Teachers could create projects, form a learning	Assessment tools were not integrated into the system. Did not provide customized instruction. Interaction was limited. Training was needed for the parents. Could not exchange information with other systems.

(*continued*)

Table 1. (*Continued*).

LMS	Benefits	Limitations
	community, manage instructional media, and organize assignments. *Communication:* Provided online access; facilitated collaboration; provided parental access.	Was a complex system, not easy to use. Its management capability was limited – did not provide progress reports for students. Upgrading the system was problematic. Did not keep individual characteristics. Roles of teachers, students, and parents were not clearly defined.
Data Mine	*Record keeping:* Kept family information and test scores; gathered information from Skyward, NWEA, and ISTEP; and generated reports. *Planning*: Teachers monitored the course, what was covered, and what was to be covered. *General data:* Administrators could see all professional development.	(Not mentioned.)
Plato	*Instruction:* Used digitized text. *Assessment:* Kept the test results.	Had only digitized text, difficult to learn
Atlas	*Record keeping:* Kept student records. *Planning:* Teachers could create curriculum maps; offered media and materials management.	(Not mentioned.)

technological literacy – as in PeBL and, therefore, not all the learning outcomes for New Tech High School students could be uploaded to the system. See Table 1 for a summary of these findings.

Odyssey: With this system, teachers could create lessons in line with their objectives, and the system was able to generate a list of lessons in accordance with the state's academic standards. Odyssey was said to be more intuitive, and to have a video clip of an actual teacher teaching a lesson. On the side bar of the same screen, the students could see the notes on important details of that teacher giving the lesson. In the third portion of the window, the teacher wrote notes or gave explanations during the trials. One of the participants indicated that "It is a lot more interactive, like the teacher is actually teaching a lesson, and it is a very flexible system" (Technology Coordinator A, 8 April 2009). Another participant pointed out that "The tool is designed to accelerate students' learning" (Administrator A, 24 March 2009). The lessons in the system were customizable, and activities could be assigned to either a student or a group. It had project activities, but they were not used by the teachers. The system provided individually paced instruction. It was interactive, and parents could monitor their student's progress. A variety of reports (attendance, learning report) could be generated for use by administrators, teachers

and students, and it was tied with NWEA. The system created a learning path based on the score that students got from NWEA. CompassLearning was the version of Odyssey used in the high school. It was stated by some of the participants that the tool was cost effective to maintain, was user friendly, and provided interaction for students. The *benefits* of the system pointed out by the participants were: availability and customizability of the lesson templates in the system, online access from outside the school, video availability, and user friendliness. *Limitations* of the tool mentioned were: even though the tool's licensing for the high school was for unlimited users, it was for a limited number of users in the other schools in the district, which created accessibility problems for the students and staff. However, this is not an inherent limitation of the LMS.

NWEA (Northwest Evaluation Association): The technology coordinators indicated that NWEA was developed based on artificial intelligence. Four participants stated that the tool supported individualized and mastery learning. It did not allow the user to go to the next topic unless s/he completed the current one. It provided an online classroom through Odyssey. After taking a test in NWEA, a learning path was created in Odyssey based on the results of the test. One of the interviewees affirmed that "The system is easier to manage. It provides summative assessment in nature but it is more toward formative assessment. It lets us know where the students are instructionally at that point of time." (Technology Coordinator A, 8 April 2009). It provided credit recovery that enabled students who were failing a course to receive course credit without repeating an entire year of school, and intervention programs for the students who could not understand the classroom instruction. The most important *benefits* of the system were two. It determined students' mastery level. The system operated automatically, and it also had a teacher interaction system that enabled teachers to create and modify student-specific lesson plans. The participants did not mention any *limitations* or information-age features of the tool. A summary of these findings is provided in Table 1.

PeBL: This tool was used only in New Tech High School in the district. It was used for project-based learning. The teachers could create projects, form a learning community, manage instructional media, organize assignments, and use the tool for grading. It had a Web component, and parents and students had access to the system. PeBL had a project library where the teachers could upload and download projects. PeBL was also used to keep records (grades) and to generate extensive student reports. It facilitated collaboration to form a learning community. One of the participants mentioned that "it implemented Carnegie learning principles" (Technology Coordinator A, 8 April 2009) that highlight the importance of prior knowledge, organization of knowledge, motivation, mastery learning, goal-directed practice, feedback, and each student's developmental level in the learning process. The *benefits* were described as follows: PeBL facilitated communication and collaboration; it had a project library; students' activities could be monitored; and it was accessible by parents to monitor the calendar and their student's assignments. The *limitations* of the tool mentioned were that PeBL did not provide customized instruction and did not keep individual characteristics that could influence learning; only the teachers could assign projects or assignments to the students; the system was unable to determine each student's level and create a program for mastery; an assessment tool was not integrated into the system; even though the system facilitated interaction, it was limited; the system did not provide progress reports for

the students; the teachers needed to prepare digital materials most of the time themselves; the roles of teachers, students, and parents were not clearly defined in the system; it was not easy for parents and teachers to use – training was needed; the system was difficult to upgrade and didn't provide instructions for customization; the system could not communicate with the other systems used in the district; the system's management capability was limited. A summary of the findings is presented in Table 1.

Data Mine: Four participants indicated that Data Mine was used to keep family information and test scores and to create reports. Basically, it pooled information from Skyward, NWEA, and ISTEP (Indiana's standardized test). After that, it put those links together for the teachers' use. Data Mine used a software program called MMiSi for management purposes, which offered curricular mapping used by teachers, administrators, and technology coordinators. While teachers mapped out their particular courses to see what students did and what they were going to cover, the administrators mapped out all of the professional development, and this allowed them to determine the professional development needs for the school. Additionally, Data Mine helped teachers organize the class and plan course work based on students' needs. One of the interviewees commented, ''With this monitoring, you know your students, and even before they come to the class, you can sit down over the summer or in the beginning of school year, and plan out the classes differently depending on what is needed in each classroom. For the administrators, it provides a great quick access for a personal emergency situation such as knowing the students' schedule'' (Administrator A, 24 March 2009). The important *benefit* of the system as indicated by the participants was quick access to student data, to monitor students' achievement level in a particular course. This helped tailor the lessons based on each student's needs. The *limitations* of the system were that it was not possible to change or adapt the information in the system, and it simply extracted information from other systems used in the district.

Plato and Atlas: In addition to the above-mentioned LMSs, the district had *Plato and Atlas*. Plato required teachers to keep up with how the courses were structured on a daily basis, and it had only digitized instructional text, which made it difficult to learn how to use and use efficiently. It did not have online access. In this system, students read, answered the questions and clicked, and they continued with the same cycle. Test reports could be generated. There were problems with Plato in terms of system management. One of the interviewees stated that ''Unless you are adding students to and keeping up with how the courses are structured on a daily basis, you have to go back and relearn the design'' (Technology Coordinator B, 8 April 2009). It seems that Plato was a problem for the teachers. Atlas was used for curriculum mapping, media and materials management, and record keeping. Teachers mapped out their particular courses, administrators mapped out all their professional development activities, and teachers could see what the administrators had done. Administrators also referred back to the human resources in regard to professional development activities at the school level. However, it was not used very often by the participants.

The third research question

(1) What are the participants' opinions about how well the information-age functions are served by the LMSs they are using?

For this question, the results are organized according to whether the information-age functions elaborated in the introduction were served or not served.

Information-age functions served

Participants mostly talked about Odyssey, NWEA, and PeBL. According to the participants, some of the information-age functions facilitated by the LMSs were curriculum mapping, customization, data management, interactive communication, collaboration, personal attainments and project-based learning.

Participants indicated that customizability, assigning activities to either a student or a group, and personal attainments were the information-age functions served by Odyssey. Even though the system did not have its own assessment system, it was linked and worked very well with NWEA, according to the participants.

Another LMS that supported the learner-centered paradigm according to most of the participants was PeBL, which provided three primary functions (record-keeping, planning, and instruction) and the communication function. The tool facilitated project-based learning; it promoted students' collaboration and interaction; and through the tool, students made a contract before starting a project and identified their short-term goals (see Table 2). Even though the system had a project/problem library, most of the time, the teachers needed to adapt existing projects/problems or create new ones in accordance with the students' needs. One of the participants stated that ''most of the functions and work were done manually by the teachers in the system'' (Teacher A, 29 April 2009).

Information-age functions not served

In relation to the information-age functions *not* served by PeBL, the interviewees indicated that the system did not provide customized instruction and did not keep track of individual characteristics that could influence learning. An assessment tool was not integrated into the system. Even though the system facilitated interaction, it was limited. The system did not provide progress reports for the students, and the teachers needed to prepare digital materials. In addition, the roles of teachers, students and parents were not clearly defined in the system.

The fourth research question

(1) What are the participants' opinions about the information-age features that an ideal LMS should have?

Information-age functions that an ideal LMS should possess

The participants indicated their preferences for what an ideal LMS should possess as information-age functions. Even though they were all interrelated, the participants' suggestions can be categorized into three groups: (1) students' learning, (2) assessment, and (3) system-related suggestions. In relation to *students' learning*, the participants identified the following functions: offer problem/project-based learning, facilitate collaboration among students, keep track of individual student characteristics that could influence learning, and provide students access to

Table 2. Information-age functions of the LMSs.

		Roles	Odyssey*	NWEA*	Skyward	PeBL**	Data Mine	Plato	Atlas
Primary	Record keeping	Standards	√	√					
		Personal attainments	√	√		√			
		Personal characteristics							
	Planning	Long-term goals	√	√		√			
		Current attainments	√	√		√			
		Short-term goals	√	√		√	√	√	
		Projects				√			
		Teams	√			√			
		Roles				√			
		Contracts				√			
	Instruction	Instruction	√			√		√	
		Project initiation				√			
		Project support				√			
		Instructional development	√			√			
	Assessment	Authentic tasks				√			
		Performance	√	√		√		√	
		Feedback	√	√		√			
		Certification	√	√					
		Developing assessment							
		Improve instruction and assessment							
Secondary	Communication					√			
	Data administration					√	√		√
	Personnel information						√		
	LMS administration								

Note: *Odyssey and NWEA linked and worked together. **PeBL: Even though it offered many information age functions, most of these functions were performed by the teachers, not by the tool itself.

free academic resources (open educational resources) such as projects, tutorials, webquests, videos, and podcasts. In existing LMSs, students have access only to the resources determined by the LMS provider or provided by the teacher. Access to free academic resources allows students to examine multiple views in multiple formats. Regarding *assessment*, the participants suggested an LMS should have an integrated assessment tool that helps monitor students' progress and mastery level. One of the participants suggested it should allow students to record their voices with the microphone so, they can monitor their progress in reading fluency, and the system can provide feedback about it. Both the machine and the teacher should give feedback, and the LMS should provide a quick diagnostic test on student performance. The participants emphasized monitoring students' progress and mastery level as an important aspect for an ideal LMS. Since most of the instructors commented that assessment was a time-consuming task, especially when the student learns at a different pace, an integrated assessment tool seems to be essential. The system could reduce teachers' workload and at the same time improve students' learning by providing customized feedback. With respect to the *system*, the participants indicated that a single system should possess all the above-mentioned features. They mentioned the system should have a well-designed infrastructure that enables customization, provides fast and easy access to information, and is easy to use and reliable. The interviewees noted that how a single system can possess all these ideal features needs to be discussed among educators and LMS providers.

Discussion and conclusion

In this study, we interviewed teachers, administrators, and technology coordinators about the ways they used their LMSs, their opinions on the benefits and limitations of those LMSs, and their preferences for information-age functions for an ideal LMS.

Among the LMSs we investigated, PeBL and Odyssey, linked with NWEA, seemed to have the closest match with functions needed for the information-age paradigm of education. However, we also noticed that each of the LMSs still had some significant limitations, for none of them provided all the information-age functions of PIES. While some of the LMSs focused only on assessment, others focused on record keeping or instruction and learning. It can be concluded from the findings that among the LMSs we examined, there is currently none that has all the information-age functions identified by Reigeluth et al. (2008). We recommend schools to be aware of the strengths and limitations of each LMS, and employ the best ones that can be utilized together to meet their needs for the time being.

For example, Odyssey and NWEA can be used together. Odyssey is very useful for instruction, since it has rich interactivity and customizability features for instructors, whereas NWEA can particularly support formative assessment, since it shares information about student mastery levels and learning paths with Odyssey. Skyward and PeBL can also be used together. Skyward is a good tool for database management, since it effectively extracts student data, while PeBL can be useful for project-based activities, since it provides various features to support students in uploading projects as well as teachers managing student contracts.

The following are some of the most important findings of this study:

(1) To meet the requirements of the information-age paradigm, LMSs need to support collaborative learning inside and outside the school in order to extend the learning environment to the home and further involve parents (also supported by Taylor, 2004).
(2) An LMS should provide customized instruction in accordance with individual student characteristics.
(3) Integrated assessment systems need to better address personalized assessment, progress tracking, reporting, and responsiveness to learner needs (advocated by Reigeluth & Garfinkle, 1994); and they need to better develop LMS formative assessment functions that teachers can use with more innovative learner-centered pedagogical approaches (recommended by Otsuka, Rocha, & Beder, 2007).
(4) Learning management systems need to truly become systemic, by integrating all important functions seamlessly ''to allow for improved collaboration across functions and among stakeholders'' as indicated by Sherry (as cited in Watson & Watson, p. 32). Since it is unlikely that one provider could create such a fully integrated, systemic LMS, it seems advisable that LMSs be designed to be interoperable, preferably in an open-source framework as an open educational resource for which ''apps'' could be available for a fee or for free, much like apps for the iPhone, only capable of sharing information with each other.
(5) Learning management systems should be easy to use and customize by the users, and should not require extensive training.
(6) Improved training and support for using the existing LMSs is needed for all stakeholders, especially teachers.

Even though some or all of the findings of this study may not generalize to other LMSs or school districts, LMS designers and developers may judge some of these findings useful for improving their systems. These findings may also be beneficial for practitioners in selecting and using LMSs for their school systems. One of the limitations of this study is that no students could have been included in the study. We want to encourage other researchers to conduct similar research in other school districts with other LMSs by also including students in interviews and observations. Their perspectives on the same research questions may be even more enlightening than those of educators. Only this way can we improve the tools that educators so desperately need to transform their schools to the information-age paradigm of education and thereby provide a quantum improvement in meeting our students' needs.

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