

Some thoughts on the synergetic effects of combining ITS and LMS technologies for the service of Education

Kalina YACEF

School of Information Technologies, University of Sydney

Sydney NSW 2006, Australia

kalina@it.usyd.edu.au

Abstract: Principles, concepts and systems offered by the field of AIED have largely been overlooked by the discipline of Education because of differences in focus and methods. Some authors have predicted that by 2010 AIED would have the potential to make a much broader contribution to Education and communicate better with this discipline. I believe that iLMS, which can be defined as the intersection of Learning Management Systems and web-based Intelligent Tutoring Systems, could well be one of these contributions that will empower Education to create a quantum leap in teaching and learning.

Introduction

The use of web-based applications in education is becoming increasingly popular, from online tools to complement traditional educational settings to online campuses. The field of Artificial Intelligence in Education (AIED) is concerned with providing computer-based technologies using Artificial Intelligence techniques and concepts to support teaching and learning in an *intelligent* way. Its research aims are to develop principles for the design of *intelligent tutoring systems (ITS)*.

Web-based education is of significant and growing importance in Education and Training as well as in the commercial landscape. As historical data of its use becomes available and reflection becomes possible, two major questions have arisen: Can web-based education do at least as well as traditional education? Does web-based education present significant advantages compared with traditional education? There is a need to bridge the gap between web-based education and traditional education and also to exploit the advantages brought by internet and computing technology to enhance teaching and learning dramatically. The various authors of [1] advocate using contemporary technologies to improve the quality of existing higher education, rather than to replace it.

The AIED community has devoted a lot of work over the past four decades to invent principles and tools to enhance individualised learning. However its relationship with the Education field is unclear and brittle. Educationalists explain the reason for this by emphasising the fact that AIED research focuses on individual tutoring [2, 3] whereas the discipline of Education is, as Cumming & Mc Dougall argue in [4], the study of learning in groups. The model of individual tutoring is of side interest to Education because it does not really provide solutions to its core issues. Human teachers know how

to do a good job in a one-to-one teaching setting. They are more interested in methods and principles for classroom settings, which usually corresponds to their reality. In addition, AIED research favours precise models of learning, whereas Education specifically dismisses precise theory and promotes practical understanding based on rich conceptions of learning. As a result, Education, which should be the purpose of AIED research, is not much aware of that field and is reluctant to make use of it. Finally, there is still an underlying belief that the aim of using “Artificial Intelligence” in teaching is to rival human teachers and replace them.

I believe that intelligent Learning Management Systems (iLMS) have the potential to bring Education and AIED closer. In particular, I think that integrating AIED principles with LMS technology and power can have a synergetic effect to the benefit of both Education and AIED. Section 2 describes the origins of iLMS. Section 3 explores the potential benefits. Section 4 summarises the reasons why iLMS can be potentially attractive to Education, then comes the conclusion.

1. From LMS and ITS to iLMS

The World Wide Web has opened new avenues for computer-based teaching and learning in the last 10 years. There are two major stream of Web-based Education systems: (i) the newly emerged Learning Management Systems (LMS), which focus on the management of learning contents and on the administrative support (lectures, chat rooms, task management and so on). For example WebCT [5], Blackboard CourseInfo [6], Lotus Learning Space [7], dotLRN/OpenACS [8] are now used by thousands of educational institutions. (ii) web-based ITS, which focus on the teaching aspect. These are either reconsidered and redesigned from stand-alone ITSs systems (ELM-ART [9], Web-based Logic Tutor [10]) or built from scratch such as [11].

LMSs are a framework that supports teaching and learning and are usually used to support classroom education. Typically they provide management, distribution and sharing of learning contents, student tracking, assignment management, and online peer collaboration. They aim at providing flexibility, accessibility and convenience to their users.

The concept of LMS is still relatively new. As historical data becomes available, some authors have studied the pros and cons of LMS and, in general, online education. Whilst they have recognized advantages, they can also bring a lot of user frustration [1, 12]. Some of the problems identified in the literature are the student’s frustration of feeling lost in the mass, of not receiving appropriate and timely feedback on their work, of feeling isolated. On the teachers’ side, time consuming tasks, poor visibility of students’ progress and problems seem to be dominant.

ITS technology, in contrast, provides a very domain focused and individualised environment for learning with a much greater insight on the student learning style, difficulties and progress that allow the system to diagnose and remediate. For example ITS can capture mistakes as well as correct answers, steps in delivering the answer as well as the final answer. ITS embed Artificial Intelligence techniques and principles to support individualised learning. As with all systems involving Artificial Intelligence techniques, the word “intelligent” means that the design of these principles involves the

modelling and representation of relevant aspects of knowledge. In an ITS, it can be the knowledge the system has about the user, about the domain taught, about the teaching strategies, about the communication. Whilst the focus of “intelligence” in an ITS varies, generally the minimal common feature is the personalization, or adaptation, to the user. This means that the system infers, updates and stores information about the learner in order to adapt format, content, teaching objectives and feedback to the individual learner. They capture significant information about each student’s knowledge and misconceptions, answers and mistakes and store the relevant information about each specific user is stored in a student model. This information is then used to offer a close monitoring of the student, with tailored and timely feedback and exercises. ITS (web-based or not) focus on the student’s needs and involve some form of cognitive evaluation of learning based on individual learning models. In contrast, LMS focus on learning content management and administrative support. The level of adaptation provided is based on where the student has been, not on the analysis of their performance or of their learning.

A great contrast between ITS and LMS is that ITS were initially focused on a one-to-one tutoring model. Students can practice on their own, but are usually isolated unless the system specifically addresses communication between peers, such as Intelligent Collaborative Learning systems. These systems explore the paradigm of collaborative learning, where collaboration of the human learner can either be with an artificial co-learner [13-15] or with other human learners [16-18].

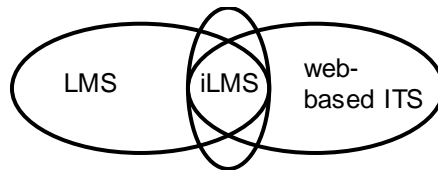


Figure 1 - LMS, web-based ITS and iLMS

My view is that Intelligent Learning Management Systems (iLMS) contain the intersection of these two streams. As with ITSs, some modelling and representation of relevant aspects of knowledge such as the knowledge about the user, about the domain taught, about the teaching strategies, and about the communication, are involved. If we consider the adaptation feature, which is predominant in ITS, we can say that in addition to the LMS features, iLMS provide adaptation to the learning state of the student. This means that an iLMS needs to have some knowledge about how the student learns and what his/her difficulties and learning stage are. Most importantly, I see iLMS as an instrument that teachers use in the design and the management of their teaching, in the same spirit as LMS.

2. Integrating the two: exploring the new avenues

We can foresee that iLMS, being a blend of these two technologies, can provide the sum of the benefits of LMS and ITS and, where they complement each other, offset their respective disadvantages. For instance, the students’ feeling of being lost in the mass whilst using LMS can hopefully be improved with an iLMS providing individualised

feedback and help. Also, iLMS have a strong focus for group learning, hence alleviating the too individualistic model often found with ITS and neglected by Education.

Moreover, I think that iLMS can somehow yield much greater benefits than the sum of these two for learners as well as for teachers, who are, after all, also users of the system. They have different roles, but helping learners means helping teachers and vice-versa. Let us discuss them in turn.

Students. Bringing AI techniques inside LMS has the potential to move away from the model of a well-organised communication channel towards an intelligent mediator. Students could benefit from a wider range of learning activities and in particular from better/more intelligent support for collaborative learning. An iLMS could act as a knowledgeable mediator for fostering students' collaboration and interactions, sharing of ideas and social creativity. This is not a new concept for AIED ([16, 17] but it could be opened up in the direction of work such as Muehlenbrock, Tewissen and Hoppe's Framework System for Intelligent Support in Open Distributed Learning Environments [18]. Whilst LMSs already provide infrastructure for this, an iLMS would also have the knowledge needed to spark up and maintain fruitful collaboration between students. This knowledge can be about the topic (in the same way a professor would guide a reading class, asking the right questions at the right time) as well as cognitive techniques to challenge students' beliefs such as playing the devil's advocate, criticising students' answers to support creativity in learning [19]. Finally the fact that iLMS are web-based opens up a much wider learning community for students, with more sub-groups of interests hence more support for students.

Teachers and educators. The simple fact that iLMS potentially handles such a large amount of information concerning each student's knowledge, misconceptions, learning style, difficulties, progress is novel. Potentially, not only the students' results but also their detailed answers and *steps in delivering their answers including the mistakes made along the way* are available electronically, stored in the student models, and this for *all* the students. From an education perspective, this can really provide teachers and education researchers with an unprecedented source of data to perform empirical studies. In [4], Anne McDougall mentions her "striking experience" with BUGGY, an ITS for maths teaching [20] where she and her colleagues discovered with excitement the numerous ways in which children could make mistakes. Beyond the actual use of the system and whether it was actually yielding efficient results, it provided education specialists with a valuable insight on how children learn and was deemed useful in that regard. Similarly, teachers could exploit the data stored by iLMS to gain understanding about a quantity of aspects such as:

- how *their* current students learn. I will just give a few examples: do they learn at the same rate? Do they make the mistakes the teacher expected? Do they learn from their mistakes or keep doing the same mistakes? Was feedback A more efficient than feedback B? Is there a correlation between a specific prior knowledge and the subsequent learning?

Various authors [2, 21, 22] stress that the teacher must know something about *how students learn*, and *what to do to make learning possible*. Furthermore, a number of research studies showed that student's prior knowledge is a very strong factor influencing learning, both in a positive and negative manner. Prior correct knowledge accelerates the learning process whilst incorrect knowledge (misconceptions) can

inhibit it. Adequate teaching objectives will build upon the student's correct prior knowledge and also address the correction of misconceptions. It is therefore extremely important that teachers have a deep understanding of the students' prior knowledge in order to adjust their teaching accordingly. The role and impact of misconceptions on the learning process have actually attracted a lot of research, both in the Education field and in the AIED field ([20, 22, 23]). Ramsden advocates that to achieve teaching excellence, students' understanding (and misunderstandings) of concepts should be *constantly monitored* [21] and, as Laurillard states in [2], "the ways in which a concept can be understood is an empirical question, not a logical one". However it is hard for conventional or distance learning environments to undertake this sort of close monitoring, due to high student numbers and high academic workloads. iLMS have the potential to help teachers and educators perform this.

- how the students' learning patterns over years, within the same course or domain of study. This could help identify standards against which later changes (in the curriculum, the teaching strategy and so on) can be evaluated, or to compare several student populations and estimate the impact of various factors. For instance, do Australian students encounter the same difficulties, produce the same mistake, progress at the same rate as French students? Can teachers get an insight on the real impact that a curriculum and an approach have on subsequent learning courses? These types of empiric evaluations are investigated by educators. iLMS would make this task much easier.
- checking whether their teaching is improving over years. Education is very concerned with teacher training and maintaining high level of teaching quality. Such a large amount of cognitively detailed data could help teachers reflect on their practice. As emphasised in [24] "[The] recognition [of the quality of teaching and learning] is linked to the current emphasis on the need for accountability to stakeholders and especially to funding agencies, and to the growing competition between institutions for resources and students.... Staff need to gather data about teaching and learning as evidence of the quality of their teaching and their students' learning. However, as Ramsden et al (1995, p.97) note, "Academics are unskilled at presenting a case for their performance in teaching; members of promotions committees typically receive information which consists of a list of activities and responsibilities. It is impossible to judge a case reliably on such evidence". Therefore, it is important that staff and institutions develop appropriate, valid and reliable strategies for gathering information on teaching and on the quality of student learning". I think that the amount of information that can be gathered through iLMS about student's learning can be used by teachers to document their cases (along with any other evidence they gather traditionally).

Finally, helping teachers has a rippling effect on students. Helping teachers means providing students with better, more efficient, more knowledgeable, more adaptive teachers.

3. Foreseeable difficulties

The integration of LMS with ITS is not straightforward. It is easy to see that it will create new avenues for research and reinforce some existing ones by placing them in a more crucial context.

ITS technology implies some modeling of the domain knowledge, which the system needs to be able to assess the students' answers and infer some information about their learning, and adapt the interventions. However, LMS are by nature generic. This raises the important question of finding methods to model the domain in a dynamic way. Many AIED researchers have studied this problem when working on ITS authoring tools (see [25] for a quite recent state of the art). Sometimes the modelling of the domain can be by-passed to a certain extent with computerised learning companions, learning with the student and constructing their own knowledge through cooperation [15].

The same thing applies to the problem of student modeling. LMS are much broader than ITS. For example we would expect an iLMS to cover the whole curriculum of a course, and cater for various communities of learners, potentially with very different backgrounds, interests and goals. In an ITS, student models only need to capture information that will be relevant to the adaptation of pedagogical interventions within a specific teaching context. In iLMS, this teaching context varies greatly, therefore it will need to capture a much broader bandwidth of information about the user. Moreover, iLMS are much more likely to provide more unrestricted interactions, including natural language, which is an intractable problem in student modelling, and require the modelling of groups as well as of individual learners. Research has already taken place around this issue [26, 27] and will be reactualised in light of iLMS.

4. Why would iLMS contribute to bridging the gap between Education and AIED?

As Cummin and McDougall [4] argue, AIED embraces Education and Cognitive Science, but the converse is not occurring. One of the reasons for which ITS, and in general the field of AIED, have been dismissed by the discipline of Education is precisely because of its lack of orientation towards group learning (in spite of the work on collaborative learning systems). As it is, Education mainly pursues the study of learning in groups and the study of groups of learners. A second reason is that AIED exploits precise models of learning, whereas Education in fact dismisses precise theory and promotes practical understanding based on rich conceptions of learning. Moreover, the 'AI' label creates fear that AI programs would be used to replace teachers rather than help teachers do their job even better.

It appears that iLMS have the potential to be more attractive to Education for various reasons, outlined below.

Teachers in control

In addition to the benefits cited earlier, a very important aspect of iLMS is that electronic detailed data about students' steps and misconceptions are *potentially available to the*

teacher, for him/her to use in the way s/he wants to. This is very important. It means that teachers are not replaced or competed against but empowered with new information and new tools. iLMS do not have to aim at providing solutions for people to learn better (which would hence follow a precise model and receive criticism from Education). Just providing tools to help educators get more answers on the questions they want is potentially of great interest. iLMS would not provide solutions as such but rather help teachers and educators to find *their* solutions, using *their* methodologies. Of course, some iLMS designers may build systems that restrict the use of this information by the teachers, and this may be disliked by Education. But at least the information should be retrievable with little work.

Reinforce the frail yet crucial relationship between teachers and students

iLMS models some aspects of the valuable direct contact that can occur when the ratio between teachers/ facilitators and students is low. They provide individualised assistance to the student whilst recording data for the teacher to work with, mimicking in some aspects the role of a human teaching assistant, which is a familiar concept in Education. I call systems that use this concept Intelligent Teaching Assistants [28].

Power of moving to group learning and study of groups.

Instead of focusing on individual learning or helping individuals to collaborate with each other, iLMS support group learning as well as individual learning. Access to such a rich collection of data will allow teachers and education specialists to study underlying learning processes of groups of students. The subtle reason why iLMS may be more appealing than Intelligent Collaborative Learning Systems (ICLS) is that iLMS can be perceived by Education as being an LMS (which is accepted to a certain extent by educators, partly because they are perceived as mediating and communication tools rather than teaching tools) with extra features whereas ICLS are associated with ITSs.

Teacher reflection tool

Teachers can use iLMS data to assess their own practice over years and have an insight on the impact of a new teaching curriculum, or method, or assessment. Qualitative assessment of teaching and learning, as stressed earlier, is a priority for Education, who would hence welcome this feature.

5. Conclusions

Web-based education offers very powerful advantages that are currently under-exploited. There is a need to create smart ways of using this type of teaching in order to provide a *new* kind of support to teaching and learning. It seems that iLMS have the potential to provide a brand new insight on learning and to open up new kinds of analysis and use in teaching. They may have a greater popularity in Education than ITS systems, partly because they can provide assistance in issues that are of strong interest to Education such as the study of individual as well as group learning and the monitoring of teaching quality, and because they have the potential to empower human teachers to address them. These prospects are also expected to lead to new research areas and to expand existing ones within AIED and Education.

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My research interests lie in the area of Artificial Intelligence in Education. I am a partisan of the concept of *intelligent assistance* within this field. My view is that human intelligence and creativity are very powerful and my motivation is to keep humans in the loop and to empower them with intelligent artefacts and tools in order to help them do their work better. I also have interests in web-based education, organisational training, data mining, ontologies and knowledge representation.

I am a Lecturer at the School of Information Technologies, University of Sydney, Australia, where I teach Artificial Intelligence, Formal Languages and Logic.



Kalina Yacef