A Web-based Learning Management System with Automatic Assessment Resources to Support the Diversity of Learning Rhythms

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Abstract. Web-based Learning Management Systems are welcomed to support the teaching and learning process. Such systems can help learners to create their own schedules for studying, since the content to be learnt is available in the system for a period of time diverse from a class, within a school, in a specific schedule. However, whenever the learning process is mediated by a web-based learning system, the delay on providing feedback may cause student's disappointment or course abandonment. In this paper, we present a Web-based Learning Management System with Automatic Assessment Resources and some of its functionalities. The system is presented as a tool for supporting the diversity of learning rhythms that tutors face during the teaching and learning process of any subject. In addition, a report is described based on experiences that authors have been had during the last three years.

1. Introduction

Computers and internet related technologies have been used for educational purposes for some time. Existing initiatives such as the development of systems to support the management of teaching and learning activities are spread all over the world (e.g. AulaNet[1], Classweb[2], Manhattan[3], Moodle[4], Teleduc[5], WebCT-Blackboard[6]). A positive aspect of such system is that learners can follow their own rhythm of learning, meaning that such systems may support the diversity of learners' rhythms. However, most of the existent initiatives don't provide resources to support the learning of specific contents, such as geometry. Moreover, the incorporation (in such systems) of external resources (e.g. a Java applet) that supports the learning of some specific content isn't an easy task, sometimes it isn't possible at all. Nevertheless, for the best of our knowledge, except for multiple choice tests, none of them provide automatic assessment for activities performed into the system.

[1] AulaNet System for Distance Learning, http://www.eduweb.com.br/ingles/ (last visit 03/12/2007)
[2] "ClassWeb Open Source Distribution", http://classweb.ucla.edu (last visit 03/12/2007).
[3] "The Manhattan Virtual Classrom", http://manhattan.sourceforge.net/?Welcome (last visit 03/12/2007).
[4] Moodle: "A free, open source course management system for online learning", http://moodle.org (last visit 03/12/2007).
[5] Teleduc: "Distance Learning Environment", http://teleduc.nied.unicamp.br/teleduc (last visit 03/11/2007), in portuguese.
[6] "BlackBoard and WebCT", http://www.blackboard.com (last visit 03/12/2007).

In this paper we present SAW[7], a web-based system to fulfill the requirements aforementioned and how its use can support the diversity of learning rhythms. Therefore, SAW provides means for simple incorporation of content specific software components, typically Java applets, called *e-Learning Modules* (e-LM).

The paper is structured as follows: section 2 describes web-based learning systems and the denominations they may have, according to their main functionalities; section 3 presents the SAW system and in section 4 some of the system functionalities are described. Section 5 describes a report of positive results on using SAW and finally, section 6 presents our conclusions and future work.

2. Web-based Learning Systems

There are several denominations for systems that support the management of teaching and learning (T&L) activities and they are usually distinguished through their capabilities to support the T&L process. According to Nichani (2001), Kaplan-Leiserson (2007) and Itmazi et al. (2005), the most common denominations they present are: *Learning Management System* (LMS), *Content Management System* (CMS) and *Learning and Content Management System* (LCMS). In general, a LMS provides resources to manage the student learning process by storing, tracking and manipulating data related to it; a CMS provides resources for the creation, management and publication of learning contents; and a LCMS combines both, the LMS and the CMS functionalities, which allow teachers to follow the students learning process and to create, to publish and to manage the content of a course. However, there is no agreement in the e-learning community about it (Ellis, 2001). For instance, if we look for the Moodle System (2007) classification in the literature, we will find that some authors, such as Depow (2003) and Kennedy (2005) classify it as an LMS and other, such as Cole (2005), as CMS.

In this paper we will adopt the term Learning Management System in a broad sense, meaning that LMS designates any system that provides some management over users' access permissions and over specific contents related to courses.

3. SAW: The Proposed Learning Management System

SAW has its development motivated by real needs of undergraduate courses from a University. These needs were related to the increasing use of computational resources to support the teaching and learning activities and to the need of managing not even the use of such resources, but also the assessment of the produced material during such activities. A prototype SAW (Brandão et al, 2004) was developed to allow the easy incorporation of e-LMs for specific contents. The e-LMs may have resources for communication with a web server through the HTTP protocol and to facilitate the authoring and automatic assessment.

SAW was developed using PHP[8], JavaScript[9] and MySQL[10] database server and it will be sooner available as free software. The main difference between SAW and

[7] Acronym in Portuguese for Web-based Learning System
[8] PHP scripting language, http://www.php.net/ , (last visit 03/12/2007).
[9] W3C, Scripts in HTML documents, http://www.w3c.org/TR/html4/interact/scripts.html , (last visit 03/12/2007).
[10] MySQL: Open Source Database, http://www.mysql.com , (last visit 03/12/2007).

other LMSs is the ability of incorporating e-LMs to support the teaching and learning process of specific contents providing interactivity in real time, including automatic assessment (Moura et al, 2007). The use of automatic assessment combined with other system's functionalities provides support for the diversity of learning rhythms that teachers faced during the teaching activity. In the following subsections we briefly describe SAW's architecture and its course components' structure.

3.1 The system architecture

The system architecture (Figure 1) follows the client/server paradigm. In the client side there is an HTML interface that uses Java and JavaScript and which provides the use of the system and its associated e-LMs. Since e-LMs are essentially Java applets, their execution is always provided by the client. Through the HTML interface the user can login into the system and use it accordingly the access permissions that the role associated with him/her (e.g. *tutor*, *learner*, *administrator* and *tutor-assistant*) has.

The server side follows a layered architecture divided into three layers: the interaction layer, the task layer and the data layer. The interaction layer is responsible for managing and dispatching the client requisitions to the task layer, which is responsible for managing the authoring resources as well as for adapting the status of a component after any modification performed by some of the system users. The tasks results are stored in the database through the data layer. The e-LMs directory stores all the e-LMs and it is accessed through the interaction layer.

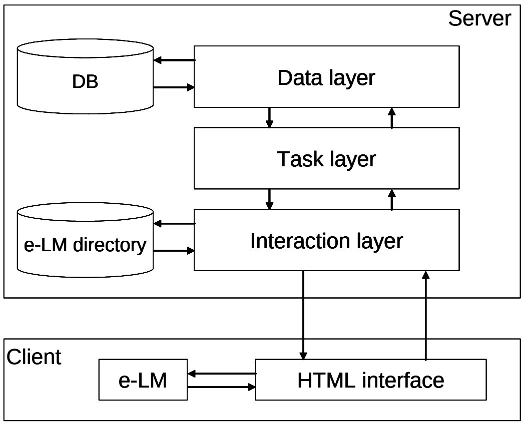

Figure 1 The SAW architecture.

3.2.1 The e-Learning Modules (e-LMs)

The e-Learning Modules (e-LMs) are content specific software components, typically Java applets which provide communication resources through reading HTML tags as applets' parameters and sending data through the POST method[11]. These communication resources are responsible for the interaction between the e-LM and the system.

An e-LM must be developed to provide support for the teaching and learning process of specific contents. They may provide resources for authoring and for automatic assessment of problems that will be included in the system as exercises or

[11] W3C- HTML specification, method POST, http://www.w3c.org/MarkUp/html-spec/html-spec_8.html , (last visit 03/12/2007).

examples. Currently, there are e-LMs concerning geometry (Brandão, 2002), introductory programming and calculus (Prado and Brandão, 2006).

The e-LM concerning geometry (iGeom) implements dynamic geometry (DG) (Bellemain, 1992) for teaching/learning geometry. It possesses functionalities for authoring geometric problems, as well as resources for automatic assessment for the problems' solutions (Isotani and Brandão, 2005). The iGeom authoring interface allows the creation of drawings, scripts and exercises. The exercise interface is related to its assessment tool. The authoring interface allows the creation of instructional content that depends on geometric objects and properties. During the authoring of an exercise, authors can hide some of the iGeom functional buttons, e.g. in an exercise for calculating the mid-point of points *A* and *B*, the mid-point button must be hidden (**Figure 2**). The authoring of an exercise begins with the use of the drawing interface (**Figure 2**, left side). At this time, the exercise statement definition and a construction that represents its solution are made. After that, the author uses the exercise interface (**Figure 2**, right side) to: (i) select objects from the drawing area that are used to describe the exercise statement and inserts them into the parameters area; (ii) select, from the drawing area, "target objects" that give a known solution to the exercise and inserts them into the answer area; (iii) click the OK button to generate the exercise. Whenever an exercise is generated, the known solution is kept hidden into it.

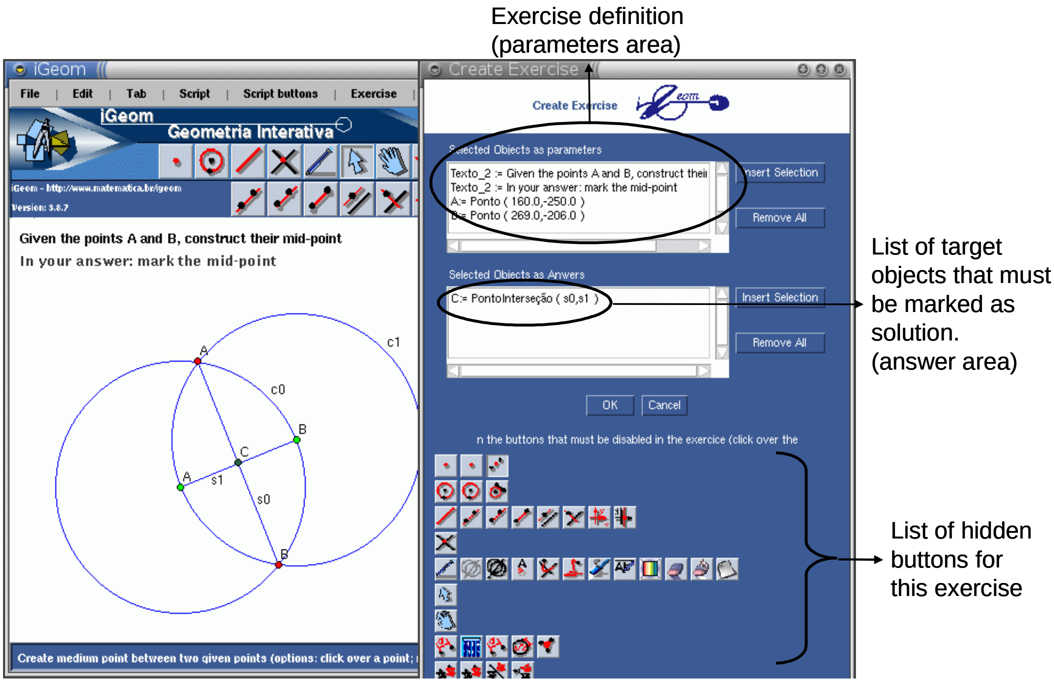

Figure 2.The iGeom Authoring Drawing and Exercises Interfaces.

The moment the learner did his/her solution and clicks the "send button" of iGeom, the iGeom assessment tool compares the learner's marked objects with the hidden target objects. This comparison is made through some metrics defined by all geometric objects from iGeom. The heuristic that establishes the exercise as correct (or not) uses a combination of metrics computed all over the target objects, in a number of configurations, proportionally to the number of free points in the exercise. These configurations are obtained by "random movements" of each free point (Isotani, 2005).

A free point is the one which is basis for moving constructions in DG for instance, in an exercise for calculating the mid-point of points *A* and *B*, the free points are *A* and *B*.

3.3 The Courses' Components Structure

The teaching and learning path of a particular subject is structured inside the SAW as linked content components and this is made to facilitate their reuse. The components are classified as *course*, *lesson*, *topic*, *exercise*, *example* and *text*. A *course* represents a discipline that is part of some curriculum. A *lesson* represents a set of activities related to a subject to be learned/taught in a period of time. A *topic* is an issue that sub-divides the subject of a *lesson*. *Exercises*, *examples* and *texts* are activities that compose a *lesson*.

Components are separated by levels: a *course* is a component of level 1, a *lesson* of level 2, a *topic* of level 3 and *exercises*, *texts* and *examples* are components of level 4. Any component of level i, for $i<4$, is composed of components of level $i+1$ (Figure 3) and *lessons* can also be composed of a set of level 4's components. Moreover, components may present a dependency relation among them, allowing tutors to establish prerequisites between an activity and a set (or subset) of activities at the same level. Whenever teachers (or tutors) establish such a dependency among components, they are creating possible learning paths to be followed by learners. For instance, it can be established that in an specific *lesson*, the *exercise* e_i depends on doing two of the activities {*exercise* e_j, *exercise* e_k, *text* t_{jk}}, meaning that the system will prevent the learner to access *exercise* e_i before the dependent tasks being successfully done, e.g. (e_j and t_{jk}) or (e_k and t_{jk}), or (e_j and e_k).

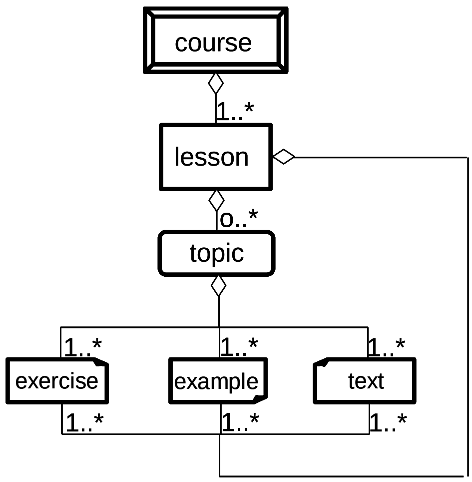

Figure 3 Components' structure.

4.The SAW functionalities

The current version of the system provides the following functionalities: hypertext editor, collaborative workplace, forum, shared download area, upload area, bulletin board, components management tools and assessment tools.

In this paper we describe just the ones related to hypertext editing, component management and assessment support. For a complete description the SAW functionalities, we refer (Moura, 2007).

4.1 Hypertext editing

The hypertext editor provided by the system is called MaRTE (*Ma*th *R*ich *T*ext *E*ditor), an extension of the RTE (Rich Text Editor) (Roth, 2007). MaRTE is a *WYSIWYG* (*W*hat *You See Is What You Get*)[12] editor that adds to the traditional hypertext editing functionalities (font size, color, format, bold, italics etc; tables editing and insertion; figures alignment and insertion) the ones related to the insertion of math formulae, bibliographic references and e-LMs objects. These characteristics turn it into a powerful interactive hypertext editing tool. In order to achieve the full potential of MaRTE, the server must have a $\LaTeX$ (Lamport, 1994) compiler.

The WYSIWYG interface of MaRTE is still under development, since it's not showing yet inserted e-LMs objects immediately after insertion. In Figure 4 we can see the editing tab of a hypertext about the Pythagoras' Theorem. The formula is shown as desired, but the inserted e-LM object that dynamically draw the theorem's proof just shows the name of the file that contains it. Figure 5 shows the publish tab and the hypertext as it will be published within the system.

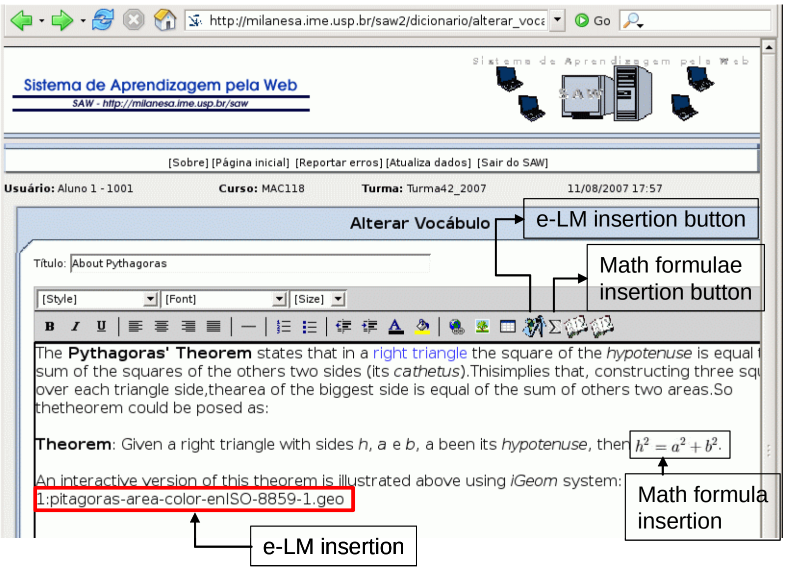

Figure 4. Editing a hypertext using MaRTE.

[12] WYSISYG, http://whatis.techtarget.com/ , (last visit 03/11/2007).

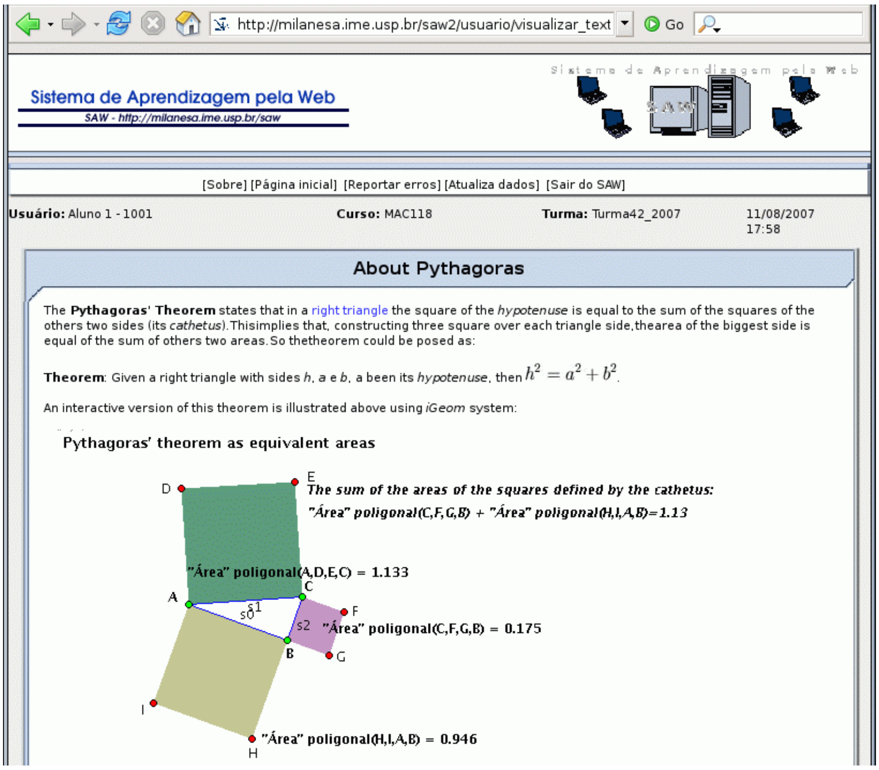

Figure 5. Hypertext published

4.2 Course's components management

The component management tools allow the *tutor* to create linkages between *lessons* and/or between a proposed set of activities. These links can represent prerequisites. For instance, if the link specifies that *lesson A* must be *completed* before the beginning of *lesson B*, the system will prevent the *learner* to begin *lesson B* before *lesson A* would be done. The definition of a *complete lesson* is due to the *tutor* and it is composed of a minimum number of activities that must be done by *learners* during that *lesson* or set of activities. In this case, if the system is using an e-LM with automatic assessment resources, an activity is considered *done* whenever it is delivered and set as "evaluated as correct" by the e-LM. Therefore, learners can follow the teaching and learning path proposed in their own rhythm, without any interference, whenever the e-LM provides assessment resources. If the e-LM doesn't provide such resources, the system marks the activity as *delivered* and the *tutor* (or *tutor assistant*) intervention is needed to analyze if the activity was properly done.

The prerequisites are transparent for *learners*, since they don't know exactly which the prerequisites of an exercise are. Currently, the system interface uses colors to show the status (*released*, *unreleased*) of a component: *released without prerequisites* are show in *black*; *released with prerequisites* are shown are shown in *yellow*; *unreleased* are shown in *red*. Therefore, he/she can solve any of the *released without prerequisites*' components, according to his/her best knowledge. A component *released with prerequisites* is turned into a *released without prerequisites* one whenever the minimum number of its associated prerequisites is properly done.

4.3 Assessment tasks' support

SAW provides resources for supporting *tutors* in the assessment task. These resources are composed of *reports* that can refer to a *class* of a specific *course*, or individually, to a *learner*. Moreover, these reports are related to each *lesson* of a *course*. Currently, the system presents three types of reports: the *class summary report*, the *class report* and the *learner report*.

The *class summary report* presents a quantitative analysis of all *learners* from a specific *class* during a given *lesson*. It shows only the scores of each *learner* for all the activities proposed for that *lesson*. The *class report* presents a qualitative analysis of *learners* from a specific *class* during a given *lesson*. It shows all the proposed LMS components related to that *lesson* and a relation (*learner* - *component status*). The component status could be: *evaluated as correct* or *evaluated as incorrect* whenever the e-LM has automatic assessment; *done* or *undone* otherwise. This report allows *tutors* to analyze the *learner* performance in each proposed activity for that *lesson*. Finally, the *learner report* presents a qualitative analysis, for a given *learner* registered in a given *course*, containing data related to his/her performance in all the *lessons* from that *course*.

Both, the *class report* and the *learner report* provide support for tutors analyzing the learner's performance but they are different views of the learner's learning process. The *class report* offers a comparative view of all learners' performance, class by class and the *learner report* offers an individualized view of a learner, showing his/her performance in all classes. Moreover, the combined use of both allows tutors to follow the learners' learning paths (and rhythms) in order to find out if and when some intervention is needed.

5. Supporting the diversity of learning rhythms: an experience report

In the year of 2004 we have introduced the use of SAW+iGeom to support the class activities of an undergraduate course for future math teachers. The course is a discipline from the Mathematics curriculum and it is about the use of computers and associated technologies as a teaching and learning tool for Mathematics. The classes occurred in a computer laboratory and learners were assisted by a tutor and a tutor assistant. This experience was made with the first version of SAW by the authors of this paper.

The course is given using the problem solving approach (Polya, 1957) and the problems are used as "problem examples" as well as exercises that include topics such as isometrics, trigonometry, "straight lines multiplication", conics, golden section and regular polygons, among others. Each topic is an activity explored by solving some problems/exercises that have their difficulty increased along it. Usually, there are 3 classes a year, 60 learners each, 2 learners by computer.

Through direct observation, before the introduction of SAW+iGeom, only small groups of learners (5 to 10 per class, in a total of 60 learners) used to actively participate on solving the proposed problems, despite the tutors and tutor assistants attempts on getting them involved. With the introduction of SAW+iGeom, the learners' participation during the class activities was individualized through their interaction with the system. All learners actively participate of each class and the goal of involving the learners in the class activities has been achieved. They were all excited with the possibility of knowing instantly if they have solved the problem correctly or not, in order to solve the next one. Nevertheless, since the problems were solved following the learners' rhythms, the time scheduled for solving them was extended from 90 minutes (the period of a class) to some days (at most a week). This could be done due to the course's component management functionality to establish possible learning paths by using prerequisites, as well as the assessment resources provided by the e-LM.

From these experiences we could observe another issue related to the learning rhythms' multiplicity: learners that solve the proposed problems in a short period of time could show their solution to others, interfering in their learning. In order to avoid it, extra problems were proposed as "challenging problems", and they could be related or not to the topic of that class. Again, the automatic assessment resources played an important role for such learners, since the challenging problems were, mostly, out of the scope of the class. The same enthusiasm on getting involved in the class activities and solving problems was observed on learners during the years of 2005, 2006 and 2007.

6. Conclusions and Future Work

This paper presented SAW, an LMS with automatic assessment resources and its use to support the diversity of learning rhythms. Some of the system functionalities were described in order to show their suitability for allowing tutors to establish different learning paths to be followed into the system and helping learners to follow the chosen path in their own rhythm. Moreover, an experience report was given based on direct observation.

The production of reports related to the learners' activities within the system in conjunction with the exercises' automatic assessment provided resources for tutors to follow the learners' performance whenever they want. Having these data, tutors can decide when and how they must interfere for helping learners.

In the current semester, we had begun a controlled experiment in order to analyze the impact over the learning rhythm of high school students by using SAW+iGeom.

As future work, some of the solutions proposed in this paper will be implemented in the context of a broader project (TIDIA-Ae) using Java Technology. We are also studying the possibility of incorporating Artificial Intelligent techniques to support the creation of personal learning paths.

Acknowledgment

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References

Aldrich, C., "*Learning by Doing: A Comprehensive Guide to Simulations, Computer Games, and Pedagogy in e-Learning and Other Educational Experiences*", Pfeiffer, 2005.

Bellemain, F. "*Conception, realisation and experimentation of software for teaching geometry: Cabri-géométre*", PhD Thesis, LSD2-IMAG Laboratory", Grenoble, France, 1992.

Brandão, L.O., "iGeom: a free software for dynamic geometry into the web", *International Conference on Sciences and Mathematics Education,* Rio de Janeiro, Brazil, 2002.

Brandão, L.O., Isotani, S. and Moura, J. G., "A Plug-in Based Adaptive System: SAAW", *Proceedings of the Intl. Conference on Intelligent Tutoring Systems (ITS'2004),* Vol. 1, 2004, 791-793.

Cole, J.R., "*Using Moodle: Teaching with the Popular Open Source* Course *Management System*", 1st Ed., O'Reilly, 2005.

Depow, J., "Technical Evaluation Report 25. Open Source Software: Two Learning Management Systems", *The International Review of Research in Open and Distance Learning*, vol. 4, #1, 2003.

Ellis, R.K., "LCMS Roundup", *Learning Circuits*, http://www.learningcircuits.org/2001/aug2001/ttools.html , (last visit 03/12/2007), 2001.

Guimarães, L.C., Barbastefano, R. and Belfort, E., "Tools for Synchronous Distance Teaching in Geometry", In *Proceedings of the 2nd International Conference on the Teaching of Mathematics (at the undergraduate level)*, Creta, 2002.

Isotani, S. and Brandão, L.O., "Analysing constructions in the iGeom: an Approach for Automatic Assessment of Problems", *Proceedings of the Global Congress of Technology and Education*, Santos, Brazil, 2005. (in portuguese).

Isotani, S. "*Developing tools in iGeom: Using the Dynamic Geometry in the Classroom and Distance Learning*", MsC Dissertation, Institute of Mathematics and Statistics of the University of São Paulo, 2005. (in portuguese)

Itmazi, J.A., Megías, M.G., Paderewski, P. and Vela, F.L.G., "A comparison and evaluations of open source learning management systems", In *Proceedings of the IADIS International Conference in Applied Computing*, 80-86, 2005.

Jackiw, R.N. and Finzer, W.F., "The geometer's sketchpad: programming by geometry", In: *Watch what I do: programming by demonstration*, MIT Press, Cambridge, 293-307, 1993.

Kaplan-Leiserson, E. "Learning Circuits Glossary", *Learning Circuits*, http://www.learningcircuits.org/glossary (last visit 03/12/2007).

Kennedy, D.M., "Student Managed Learning Management Systems: Teachers as Designers", In. Kommers, P. and Richard, G. (Eds) *Proceedings of the World Conference on Educational Multemedia, Hypermedia and Telecommunications 2005*, Montreal, Canada, 3172-3178, 2005.

Kernighan, B.W. and Ritchie, D.M., "*The* C *Programming Language*", Prentice Hall Inc., 2nd Ed., 1988.

Kortenkamp, U., "*Foundations of Dynamic Geometry*", PhD Thesis, ETH, Institut für Theoretische Informatik, Zurich, 1999.

Lamport, L., "LATEX: *a document preparation system*", Addison-Wesley, 2nd ed., 1994.

Lucena, C.J.P., Fuks, H., Milidíu, R., Laufer, C. and Blois, M., "AulaNet: Helping Teachers to Do Their Homework", In *Multimedia Computer Techniquesin Engineering Education Workshop*, 16- 30, 1998.

Moraes, T.G. , Santoro, F.M. and Borges, M.R.S., "Tabulae: educational groupware for learning geometry", In *Proceedings of the Fifth IEEE International Conference on Advanced Learning Technologies ICALT'2005*, 750-754, 2005.

Moura, J., Brandão, L.O. and Brandão, A.A.F. "A web-based learning management system with automatic assessment resources", In *Proceedings of the 37th ASEE/IEEE Frontiers in Education Conference FIE'2007*, pp. F2D-1, F2D-6, 2007.

Moura, J. "Web Learning System: Motivations and Development", MsC Dissertation, Institute of Mathematics and Statistics of the University of São Paulo, 2007. (in Portuguese)

Nichani, M., "LCMS = LMS + CMS – How does this affect the learner? And the instructional designer", http://usableweb/details/009033.html , (last visit 03/12/2007), last updated, 2001.

Polya, G. "How to solve it", Princeton University Press, 2nd Ed., 1957.

Prado, R. and Brandão, L.O., "iGraf: a proposal of a system for teaching/learning functions through the web", *Anais do III HTEM – História e Tecnologia no Ensino de Matemática*, 2006. (in portuguese).

Roth, K. "Rich Text Editor", www.dynamicdrive.com/dynamicindex16/richtexteditor/index.htm (last visit 03/11/2007).

Sinclair, M.P., "Some implications of the results of a case study for the design of pre-constructed, dynamic geometry sketches and accompanying materials", In *Educational Studies in Mathematics*, Springer Netherlands, vol. 52, #03, 289-317, 2003.