TOOL DEVELOPMENT TO SUPPORT LEARNING, IMMEDIATE FEEDBACK, AND CONTINUOUS ASSESSMENT IN LOGIC

Antonia Huertas and Enric Mor
Department of Computer Science, Open University of Catalonia, Rambla Poblenou 156, Barcelona, Spain

Keywords: Logic course, Online learning, Technology enhance logic, Intelligent tutoring system, User centred design.

Abstract: Learning logic in engineering has similar difficulties like in mathematics: a very low academic performance and a high student dropout. In this kind of subjects interactive training activities with immediate feedback are fundamental. In a traditional face-to-face logic course the face-to-face interaction with the instructor usually provides it. In an e-learning or web-based paradigm the role of the instructor should be helped by an intelligent tutoring system. In this paper we present the design and development process of learning tools for a logic course. This tool follows a student-centred design approach in order to provide the accurate tool for a successful learning experience. A general discussion of learning tools for logics is also presented; showing that this kind of topics has concrete and specific needs in online learning.

1 INTRODUCTION

Nowadays new fully online universities and an increasing number of face-to-face universities are offering academic degrees and programs via the Internet. While some programs require students to attend lectures to the campus, many are delivered completely online. In such scenario Information and Communication Technologies (ICT) are a central element of the educational strategies connected with the new educational paradigm in which the teacher or instructor is not at the centre of the learning model, now occupied by the student. In e-learning, the computer and the instructor are peripheral elements with respect to the student. In such a new situation learning methodologies, contents and resources can not simply be transferred from face-to-face lectures to a web-based classroom, and new methodologies, strategies and tools are needed.

E-Learning is based on resources and activities accessible via a computer device. These digital contents should offer a high degree of interactivity. In such context, digital resources constitute a good alternative to printed learning materials since rich media can easily be embedded to enhance the learning. Interactive activities are less linear than online book or manuals, involving instructional design techniques and more dynamic type of self-assessment or immediate feedback.

Another important advantage of e-learning and digital learning objects is that they can allow individual training while being easily delivered to a wide audience via Internet at a relatively low cost. However, the creation of effective interactive learning resources has a high human and material cost (Ritter, Blessing and Wheeler, 2003). The software for developing is also very complex and not available to every teacher or instructor.

Intelligent Tutoring Systems (ITS) are computer systems used to improve the learning process providing customized assistance and feedback to students (Kinshuk, Patel, and Scott 2001). Their main characteristic is the immediate feedback tailored to the student's particular needs.

Regarding the areas of Logic and Mathematics, educational reforms are widespread and new educational models and tools are used, not only in online learning but also in the traditional face-to-face education. New learning strategies such as personalized support, collaborative learning, integration of ITS in the learning environment and instructional model are used (Huertas, 2007).

The traditional logic course is a survey of traditional logic, including classical and contemporary logic. Special emphasis is given to the formal language and the classical methods of reasoning. A typical initial logic course contains propositional and predicate logic and special attention is given to formal semantics. Logic is in

Huertas A. and Mor E.
TOOL DEVELOPMENT TO SUPPORT LEARNING, IMMEDIATE FEEDBACK, AND CONTINUOUS ASSESSMENT IN LOGIC.
DOI: 10.5220/0002808502220225
In *Proceedings of the 6th International Conference on Web Information Systems and Technology (WEBIST 2010)*, page
ISBN: 978-989-674-025-2

this level part of mathematical logic and the subject inherits the mathematical particularities that make it difficult for students.

Students enrolled to a logic course have to acquire a set of skills and a small set of contents. The instructor has an important role when acquiring these skills and the concrete guidance and interaction with the teacher is a fundamental aspect of the learning methodology. In the online scenario, students have the same interaction needs but they are remote interacting with the teacher only using their computer. Furthermore, this computer-mediated interaction is usually text-based, providing a narrow way to have feedback. Therefore, this can become a concern when learning the logic competences.

This paper is organized as follows; Section 2 describes the needs for a specific logic learning tool. Section 3 describes the design and development process of the learning tool. Finally, Section 4 presents the conclusions and future work.

2 LEARNING TOOLS FOR LOGIC COURSES

The design and development of e-learning contents and tools should be viewed as a formal and significant project. The user-centered design (UCD) approach to technology enhanced learning can be the key element to provide a good learning experience because the student has been moved to the center of the learning process. The UCD is a general term used to describe the design where the user influences the final result. It is, at the same time, a philosophy and a process. A philosophy that places the individual user at the center to develop a product that suits his or her needs and requirements, and a design process that focuses on cognitive factors of people and how these factors are involved in their interactions with interactive products (Sharp, Rogers and Preece, 2007).

There are many different computerized learning tools for introductory logic. Among them we can consider the following groups (Humet, 2001), depending on active/passive role of the student.

The checkers (Allen and Hand, 1992), (Gottschall, 2000) and (Layman, 1999) are characterized for a quite passive behaviour of the learner. The main activity of students consists on verify a deduction or formalization. No direct intervention or feedback is delivered by the system. The feedback of the tool is restricted to find errors when the user requests explicitly the verification of the exercise be carried out. The constructors (Barwise and Etchemendy, 1994 and 2007), (Broda and Zappacosta, 2000), (Endriss, 2000) and (Gottschall, 2000, (Moreno and Budesca, 2000) are characterized for a higher degree of interactivity with the user. They provide buttons, menus and dialogues to the user for interaction purposes. This kind of tools gives the students the feeling that they are being helped in building the solution. The provers (Endriss, 2000), (Layman, 1999) and (Moreno and Budesca, 2000) are characterized by their automatism. In this type of tools the user is completely passive. The system calculates and shows the solution of the exercise in an automatic way.

Logic contents and skills are best acquired within context that allow learners to actively training (Nardi, 1997) and this has to be taking into account when study how to improve the learning activity in e-learning courses of logic. In addition to the common learning difficulties of such an instrumental subject, online learners face specific needs, mostly related with their isolation and the computer-mediated communication. There are some important aspects that should be taken into account:

- Allow interactive training activities to learn skills instead of informative knowledge (Kenny, C., Pahl, C., 2009).
- Offering immediate feedback (Melis and Ullrich, 2003) to the performance of a student.

3 DESIGNING A LOGIC LEARNING TOOL

The UOC (Open University of Catalonia; www.uoc.edu) is a fully online university with a student-centered educational model. This model takes advantage of technology enhanced learning to put each student in the center of the learning process providing them the educational contents and learning tools needed for each course. The university offers several degrees, certificate programs and master degrees. The computer science degree is the most technical program and with a basic logic course. This logic course has around a thousand students enrolled each semester and the course outline contains the usual topics of an introductory logic course.

The goal of the project described here is the design and development of a tool for learning logic, in the context of a fully online computer science

degree using a web based learning environment. This tool should provide guidance and interactive feedback to logic course students. The project follows the UCD process that includes three main phases: gathering user requirements, designing the product iteratively and finally, evaluating the prototypes of each design iteration. In addition to these phases, the UCD process applied in the design and development of learning resources and tools has to follow the specific goals for the e-learning context: a) reduce difficulty in teaching and learning process, b) improve the learning experience and c) integrate to the existing virtual learning environment. The key element of this approach is the evaluation and iteration of the design solutions.

3.1 Requirements

We had two sets of requirements. The university established a set of organizational requirements mainly related with its technological architecture and also related with the e-learning methodological model. The second set of requirements is user defined and strongly related with the logic course students.

Institutional Requirements. E-learning resources and tools have to be integrated into the actual virtual campus in terms of user authentication and look and feel. The new resources have to be placed in the virtual classroom structure, should be accessed using a standard web browser and, from a technological point of view, they should not interfere with existing resources.

User Requirements. The users of the logic learning tool will be the students enrolled in the course. Teachers will also be users but they will have more functionalities and views of the learning tool. An analysis was carried out by using focus groups with teachers and students, to identify 1) which part of the logic curriculum is proving be more difficult for learners and for which of them the introduction of the tool would add significant value and 2) students levels and needs, and 3) students and instructors skills of ICT.

During one semester an evaluation of such requirements has been done by carefully studying the results of the continuous assessment and final exams. We had several meetings with the twelve teacher's team. In those meetings, existing tools for learning logic were analyzed and evaluated as a benchmark analysis. The result of this benchmark was that none one of the tools meet the needs of the project. In addition to that, a basic prototype of the tool was build and a pilot test was carried out observing how students used this first basic prototype of the learning tool. At the end, it was clear that the more difficult part of the logic course is the formal reasoning methods (natural deduction and resolution). Another important finding was the need to integrate any kind of learning tool in the continuous assessment model of the pedagogic strategy used. This is because if the tool is not part of that continuous assessment, the students perceive the time and effort using the tool as an extra effort without clear reward.

After that analysis the main requirements for the logic learning tool were:

- Giving immediate feedback to reduce difficulty of learning the two reasoning methods for "isolated learners"
- Fostering learning of the strategies and skills characteristics of logic (specially that two methods)
- Integrated in the continuous assessment of the students
- Easy of use / Usable
- Integrated into the existing virtual classroom
- Multilingual: Catalan and Spanish.

3.2 Design and Development

After testing the initial prototypes, the developing phase was following. The coding of the tool took several months and was done by a web developer member of the team. Other members of the group supervised and comment the process of implementation which was done in an iterative way. The architecture of the tool and other technical solutions were decided in order to assure the requirements. The tool would be designed under an approach based on an architecture in three layers: interface, domain and persistence.

It is interesting to mention that the only user requirement in order to use the tool have a browser compatible with Internet Explorer 5.5 or superior or with Firefox 2.0 or superior. It is also necessary that the user has the activated Javascript (option by default of the browsers). The web pages that are part of the tool have developed using PHP for the programming in the server and HTML, CSS and Javascript. It is also interesting to mention that to store the data in a persistent way has been used a MySQL database, which allows to manage sessions in an efficient way. Finally, the development of this application requires the communication with the existing UOC servers to obtain the login information of the students. This functionality has been covered through a series of web services provided by the

UOC technicians

All the design and development were done iteratively, testing interfaces and prototypes, involving students and teachers. As a consequence some of the decisions were changed at any level after the evaluations.

4 CONCLUSIONS AND FURTHER WORK

We designed and developed a web-based learning tool for logic course. This tool also follows the ITS paradigm needed for our requirements (Hatzilygeroudis and Prentzas, 2004), especially for the immediate feedback offered: when a task is correct, when an exercise is correct, and some advise when a task is not correct. In that case the nature of the knowledge domain itself, that is, the use of formal rules of the logic reasoning method, guaranties the soundness and consistence of the automatic feedback given.

The tool is completely integrated with the rest of the learning material and with the continuous assessment model of the logic course. Students and teachers easily can track the learning progress since the tool provides statistics for each individual user, for the class group and also for the different groups. Students can see their progression level and both students and teachers can find the critic points of every stage of the learning process. The tool has been built to be modular and reusable and this will assure the easy extension or partial revision

At present, the tool is being used in the logic course of the UOC this semester. Using it in a real scenario will provide a set of usage data that will be use to improve both performance and usability of the tool. We already have a first feedback from students that consists on positive comments about the tool and how it helps them to learn the course.

On the other hand, further work will be adding new modules to cover other parts of the logic subject, improving the feedback system and functionalities, allowing comments and notes and building a mobile version, among others.

ACKNOWLEDGEMENTS

This work has been partially supported by a 2008 project of educational innovation of the UOC; and by the Spanish government grants TIN2006-15107-C02 and HUM2006-12848-C02-01.

REFERENCES

Allen, C., Hand, M., 1992. *Logic Primer*, the MIT Press.

Barwise, J. and Etchemendy, J., 1994. *Hyperproof*. CSLI.

Barwise, J. and Etchemendy, J., 2007. *Tarski's World* CSLI.

Broda, K., Zappacosta, S., 2000. *New Pandora*. In *First International Congress on Tools for Teaching Logic*.

Chou, Ch., Chan, T, Lin, Ch., 2003. Redefining the learning companion: the past, present, and future of educational agents. *Computers & Education* 40, pp. 255-269.

Endriss, U., 2000. The Interactive Learning Environment WinKE for Teaching Deductive Reasoning. In First International Congress on Tools for Teaching Logic.

Hartley, J.R., 1973. The design and evaluation of an adaptive teaching system. *International Journal of Man-Machine Studies*, 5(3), 421-436

Hatzilygeroudis, I., Prentzas, J., 2004. Knowledge representation requirements for intelligent tutoring systems. In *7th Internationa Intelligent Tutoring Systems Proceedings*. Springer

Humet, J., 2001. LSD, una herramienta didáctica para el aprendizaje de la lógica. In *JENUI 2001*

Huertas, A., 2007. Teaching and Learning Logic in a Virtual Learning Environment. In Logic Journal of IGPL 15(4):321-331

Hussain, S., 2005. Developing e-learning materials. Applying user-centred design. National institute of adult continuing education (England and Gales).

Kenny, C., Pahl, C., 2009. Intelligent and adaptive tutoring for active learning and training environments. *Interactive Learning Environments*. 17(2), 181-195.

Kinshuk, Patel, A., Scott, B., 2001. Intelligent tutoring: From SAKAI to Byzantium. *Kybernetes*, 30(5/6), 807-818.

Layman, C. S., 1999. *The Power of Logic*, Seattle Pacific University.

Ritter, S., Blessing, S., Wheeler, L., 2003. Authoring tools for component-based learning environments. In Murray, Ainsworth and Blessing (eds.), *Authoring Tools for Advanced Technology Learning Environments*, Kluwer Academic Publishers, 467-489.

Melis, E., Ullrich, C., 2003. Local and global feedback. In *Proceedings of AIED2003, 11th International Conference in Artificial Intelligence in Education*, Sydney, Australia 476-478. Amsterdam: IOS Press.

Moreno, A., Budesca, N., 2000. Mathematical Logic Tutor - Propositional Calculus. In First International Congress on Tools for Teaching Logic, Salamanca.

Nardi, B., (ed.)., 1997. *Educational context and conciousness: Activity theory and human-computer interaction*. Cambrige, MA: MIT Press.

Nielsen, J., 1993. *Usability Engineering*. Academic Press.

Sharp, H., Rogers, Y., Preece, J., 2007. *Interaction design: beyond human-computer interaction*. John Wiley & Sons Ltd.