

Advances in Artificial Intelligence to Model Student-Centred VLEs

Paulo Alves

*University of Applied Sciences of Bragança
Portugal*

1. Introduction

The challenges to the educational paradigm, introduced with the change from a teacher to a student centred paradigm, has several implications in the organization of all the educational system. The adoption of e-learning in all of the educational levels, was a huge step forward in terms of access to resources without constrains of space and time. But e-learning didn't reach the *plato* in lifelong learning scenarios, because we have a great diversity of learning contexts in universities, with more students coming back to update their knowledge when they are already in the work market. The paradigm "one size fits all" is still being applied and all the pedagogical approaches adopt the traditional lecturer centred paradigm.

Student centred learning is an educational paradigm that gives students greater autonomy and control over choice of subject matter, learning methods and pace of study (Gibbs, 1992). This approach is very similar to the Bologna Process goals in terms of student centred model based on learning outcomes and competences. Some of the characteristics of effective learners in the student centred learning paradigm are (de la Harpe et al., 1999):

- Have clear learning goals;
- Have a wide repertoire of learning strategies and know when to use them;
- Use available resources effectively;
- Know about their strengths and weaknesses;
- Understand the learning process;
- Deal appropriately with their feelings;
- Take responsibility for their own learning;
- Plan, monitor, evaluate and adapt their learning process.

The majority of virtual learning environments (VLE) are used as mere repositories of content, based on the classroom paradigm and don't support the individualization of the learning process. According to Dias (Dias, 2004), building spaces for online learning is a challenge that goes beyond the simple transfer of content to the Web. This approach tends to transform the environments in online repositories of information rather than in the desired spaces of interaction and experimentation.

To allow a greater adaptation of the learning environment based on the student's profile, is proposed the adoption of theories of artificial intelligence in education, based on the learning experience, adapting contents and contexts to the student needs.

In the last three decades, artificial intelligence has been adopted in various forms of education. The initial experiences of the adoption of artificial intelligence in education dates back to 1984. Several other approaches appeared and in 1988 one of the first architectures of intelligent tutoring systems was developed by Burn and Caps (Burns & Caps, 1988).

One of the most important issues in the adaptation of an intelligent tutoring system is the modulation of student behaviour in order to adapt the pedagogical model to the student model.

For this adaptation to be more effective is necessary to identify the student profile, based on several parameters. One of the most important parameters is the student learning style. Each student has his own style of learning, which influences the collaboration during the learning process.

In this context, the development of adaptive learning environments, based on the student profile is one of the most important challenges in the adoption of artificial intelligent systems in education, in order to improve the educational process. This approach is based on new pedagogical methodologies to provide learning environments adaptable to the needs of each student.

This chapter discusses the development of adaptive virtual learning environments, to improve the educational process, considering the student learning style and the collaboration in the learning activities.

2. Learning Styles and Student Profile

The basic theory of learning styles is that different people learn in a different way. One way to see the learning styles is to connect them with the learning cycle advocated by Kolb (Kolb 1984), where learning is seen as a continuous process based on practical experience that incorporates a set of observations and reflections.

Later, this model was developed by Honey and Mumford (Honey & Mumford, 1986) creating a questionnaire of learning styles based on the model proposed by Kolb. It was identified by the authors four learning styles, related to the different four stages of the learning cycle proposed by Kolb (Kolb, 1984): activist, reflector, theorist and pragmatist (Fig. 1).

Each learning style has the follow characteristics (Honey & Mumford, 1986):

- **Activist** - Students with an active style involve themselves fully and unreservedly in new experiences. Have an open mind, are optimistic, which makes them enthusiastic about something that is new. Tend to act first and consider the consequences later. They engage in many activities and when they lose the enthusiasm they change to another activity. The main philosophy is to try everything they can. They have great enthusiasm with the challenges of new experiences, but discourage with the implementation and consolidation of ideas. Tend to get involved in tasks with other people, but usually try all activities centred on them.
- **Reflector** - The reflector like to be more in the rear to observe and reflect on experiences from different perspectives. Collect data and prefer to think about that before making any conclusions. Its main philosophy is to be cautious. They are very balanced, preferring to consider all possible angles and implications before taking any action. They prefer to watch other people in action. The reflector people are by nature discreet.

- Theorist - People with a predominantly theoretical style incorporate comments into complex theories, but they are logical. They consider the problems on a vertical way, step by step and in a logical way. Assimilate facts based on consistent theories. The main philosophy is "if it is logical then it is good." They have an independent spirit and like to formulate principles, theories, models, assumptions and thoughts. The approach of the problems is mainly logic.
- Pragmatist - The pragmatists tend to experiment the ideas, theories and techniques for checking whether they work in practice. Having new ideas they seek for an opportunity to try it in practice. They are impatient in discussions with subjective or vague ideas. They are essentially practical and like realistic decisions to solve problems. The main philosophy is: "there is always a better way to do things" or "if it works then it's good."

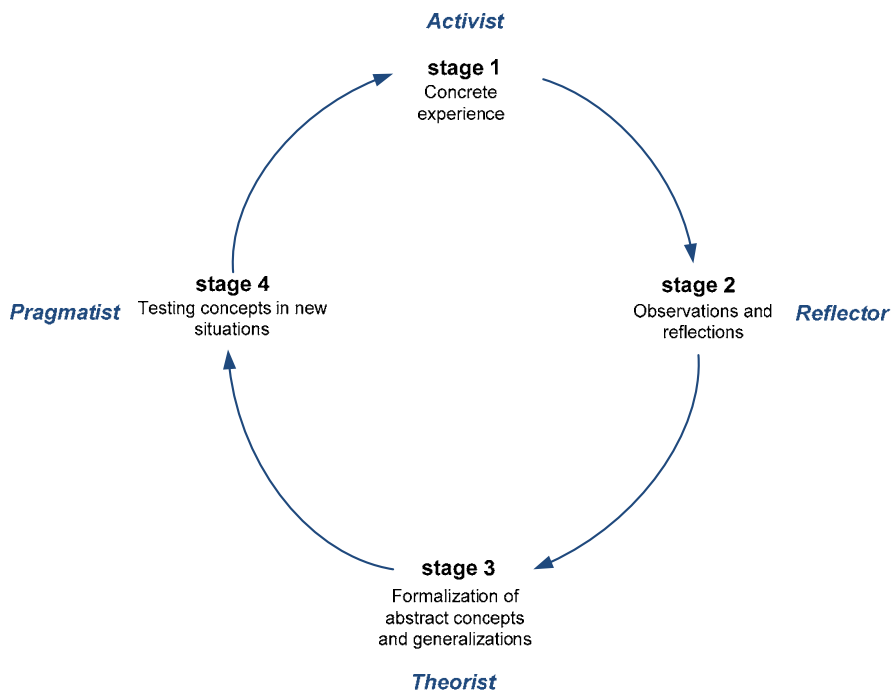


Fig. 1. Learning Styles (Honey & Mumford, 1986)

The learning styles have become increasingly important in education, given the change in the educational paradigm introduced by the transition to the knowledge society. The lifelong learning paradigm leads to new learning contexts, which are increasingly more heterogeneous, where is important to take into account the learning styles of each student to provide an education more effective and focused on the student.

Figueiredo and Afonso (Figueiredo & Afonso, 2005) consider the context and content as the key elements of the learning model. The learning model defines the learning activities as the

situation in which individuals learn. The content is the information that is structured and consists of text, materials, multimedia resources and lectures. The context is a set of circumstances that are relevant to the student to build knowledge through its connection to the content.

In this model, the teacher has a bipartite role in the presentation of content and creating the learning context. The context can be a classroom or a virtual learning environment, in which the role of teacher is more focused on content in the case of a classroom, and the context in the case of a virtual learning environment.

Contents assume the role of transmission of knowledge, where information is transformed into knowledge through a given learning activity.

The integration of intelligent systems in the learning process support, allows an adaptation of content and contexts to the learning style of each student, providing adaptive tools to support collaboration (Lesgold et al, 1992; Goodman et al, 2003).

3. Adaptive Web-based Educational Systems

The adoption of intelligent agents in education started in the end of the 1980s, based on the work on autonomous agents, intelligent tutoring systems, and educational theory.

The artificial intelligence in education has the potential to improve the learning process, adapting the materials and the learning environment to the student profile. The student profile is based on his learning style, learning needs, goals and choices.

The first systems that adopted artificial intelligence techniques were the Intelligent Tutoring Systems (ITS). Kearsley defined an intelligent tutoring system as an application of artificial intelligence techniques to teach students (Kearsley, 1987). Sleeman and Brown (Sleeman & Brown, 1982) defined an intelligent tutoring system as a program that uses artificial intelligence techniques for representing knowledge and carrying on an interaction with a student. According to Sleeman and Brown, an intelligent tutoring system must have its own problem-solving expertise, its own diagnostic or student modeling capabilities, and its own explanatory capabilities.

One of the first architectures of an ITS system was presented by Burn and Caps in 1988. This architecture was based on four main components: curriculum module, student module, tutor (pedagogical module) and the interface module between the student and the system. This basic architecture was improved by several researchers, including Ong and Ramachandran in 2003, Thomas in 2003, Bass in 1998, Choquet et al. in 1998, Titter and Blessing in 1998 and Nkambou and Gauthier in 1996.

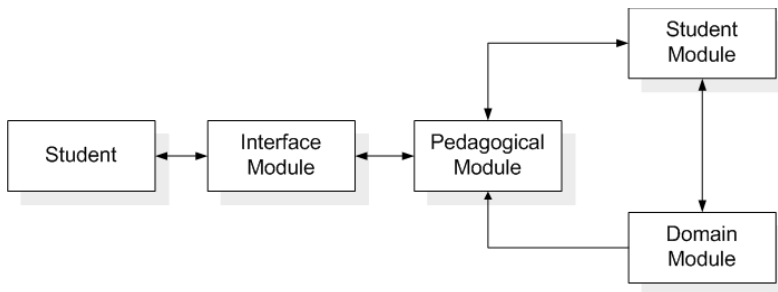


Fig. 2. Components of an intelligent tutoring system (Ally, 2004)

Modern intelligent tutoring system architectures (Fig. 2) are very similar to the Burn and Caps proposed architecture. The four modules are represented frequently as the domain module, student module, pedagogical module and the interface module.

The student has the main role in the intelligent tutoring system. All the features of the system have the mission to adapt the interface and the pedagogical material to the student profile and his preferences.

The domain module is the knowledge management system, of which all the concepts that the system pretends to transmit to the student are stored.

Connected to the domain module are the student module and the pedagogical module. The student module represents the learner's behavior, his profile, learning style, motivation level and his interests. This module is based on artificial intelligence skills that simulate the human behavior. All the student behavior is recorded in the system and used for "reasoning" and adapt the domain module to the learner's needs.

The pedagogical module acts as a virtual instructor, presenting the contents in an appropriate sequence, based on the student skills and his learning style. This is an interactive process and this module has the mission to explain the concepts to the student given several points of view and supporting all the learning process.

With the capacity to communicate and interact with the student, the interface module has an extremely important mission. If one ITS have powerful pedagogical, domain and student modules, but the interface module is very poor, the ITS will not be effective because the interface is the front of all the system and has the ability to cap all the attention of the learner. To develop a good interface module is necessary to consider the usability issues of a user computer interface, because this module interacts with the user and the other components of the system. If the interface fails all the other modules fail too.

The type of intervention of the pedagogical module within the system is very important for the student's creativity and motivation. Wenger proposed that it is more efficient to let the student search for the solution for one problem before making any sort of intervention. (Wenger, 1987).

ITS are based on computer based training (CBT) technologies and are learner centric. The main disadvantage appointed to these systems is the limitation of the student creativity, because the student needs some autonomy in the construction process of knowledge. In the other side if the system is very passive the motivation of the student can decrease quickly.

The evolution of the ITS to a multi-agent based learning environment was pushed by the new distributed learning environments. Tutoring agents and pedagogical agents are new approaches to integrate in Web based learning environments artificial intelligence methodologies.

The tutoring agents have a new role in the learning environments using the artificial intelligence methodologies to adapt the contents and the contexts to the student profile. Nwana classified agents according to three ideal and primary attributes that agents should exhibit: autonomy, cooperation, and learning (Nwana, 1996). Autonomy refers to the capacity of one agent to act without human intervention. Cooperation is the capacity of one agent to cooperate with humans and other agents. Learning is the capacity of one agent to improve his performance acquiring knowledge.

Pedagogical agents are autonomous agents that occupy computer-learning environments and facilitate learning by interacting with students or other agents. Pedagogical agents have been designed to produce a range of behaviors that include the ability to reason about

multiple agents in simulated environments; act as a peer, collearner, or competitor; generate multiple pedagogically appropriate strategies; and assist instructors and students in virtual worlds (Shaw et al, 1999)

With the expansion of E-learning, to overcome the limitation of “one size fits all” of current e-learning systems, Brusilovsky propose the adoption of Adaptive Web-based Educational Systems (Brusilovsky, 2002) supported in the theory of Adaptive Hypermedia Systems. These systems explore the features of collaboration of the Web with the adaptation features of intelligent tutoring systems.

Brusilovsky argues that the most important challenge of Adaptive Web-based Educational Systems is the combination of the features of learning management systems with adaptive content authoring tools.

De Bra et al (De Bra et al, 2006) develop and opensource Adaptive Hypermedia Architecture - AHA!, which simplifies the process of integration Adaptive Hypermedia Systems in e-learning, using a service oriented approach, to provide adaptation and customization of the learning contents. The AHA! Project is on version 3.0 released in 2007.

Adaptive Hypermedia Systems are typically rule based systems without the ability to adapt to new learning situations. To address this, is proposed the integration of case-based reasoning agents to adapt the contents to the students need, improving the sharing of knowledge in learning management systems.

4. Artificial Intelligence methodologies in education

Case-based reasoning (CBR) is one of the major reasoning paradigms in artificial intelligence, having applications in several research areas. Kolodner (Kolodner, 1992) defined CBR as adapting old solutions to meet new demands, using old cases to explain new situations, using old cases to critique new solutions, or reasoning from precedents to interpret a new situation (much as lawyers do) or create an equitable solution to a new problem (much as labor mediators do).

CBR has the advantage of the low initial training of the system, compared with other expert systems like rule-based reasoning (Yang et al, 2001) and model-based reasoning; which needs a set of rules that is related to the problems and their solutions. In CBR the relation of the problems with their solutions is obtained from experience and the system can start operate with few stored cases and the reasoning capacity increases with the number of new cases stored.

The problem-solving life cycle in a CBR systems described by Aamodt and Plaza (Aamodt & Plaza, 1994), consists essentially in the following four parts (Fig. 3):

- Retrieving similar cases experienced in the past;
- Reusing the cases copying or integrating the solutions from the cases retrieved;
- Revising or adapting the solution(s) retrieved to solve the new problem;
- Retaining the new validated solution.

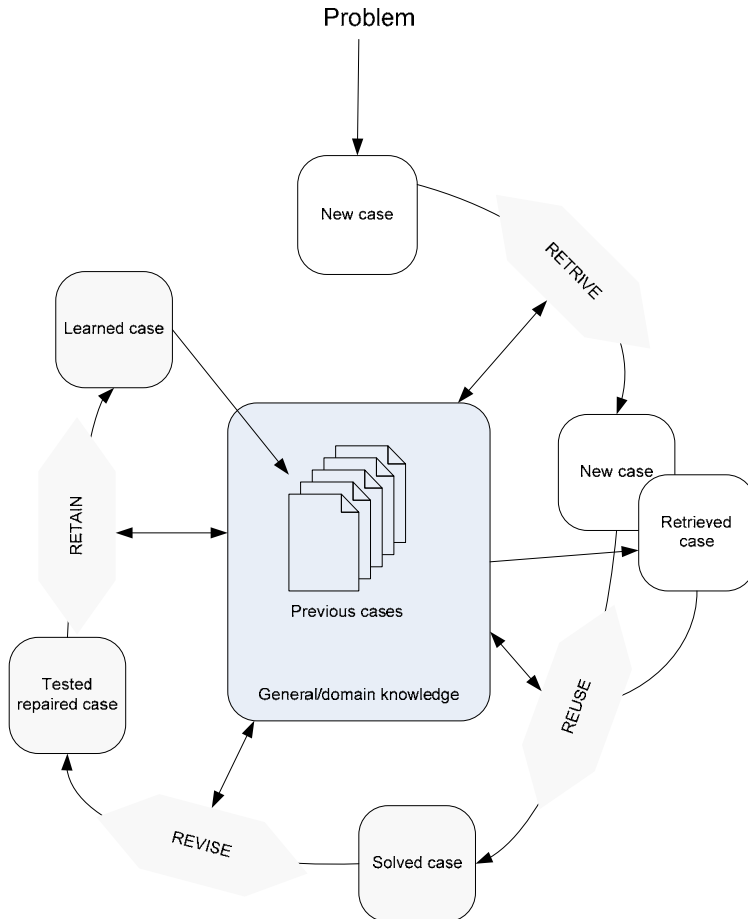


Fig. 3. CBR cycle (Aamodt & Plaza, 1994)

CBR has been widely adopted in several domains, such as medicine, diagnoses, knowledge acquisition, help-desk, design, planning, scheduling, robot navigation, image processing, electronic commerce, and maintenance.

The use of CBR in education has several advantages, like supporting the lecturers in the design of more effective learning activities and the students in order to improve their learning experience and their knowledge.

5. iDomus – An adaptive e-learning system

The heterogeneity of students in higher education will increased as a result of the demands of knowledge based economy, which demands a lifelong learning paradigm. The lifelong learning has been defined as one of the priorities of the Bologna Process. Thus, it will be

increasing the number of students in different contexts of learning. To meet these new challenges is necessary an improved customization of the learning methodologies, to support each student learning style.

The identification of the student's learning style is an important requirement for an adaptive system in order to adapt the learning environment to the needs of each student.

To implement this approach it was developed the iDomus system, supported by case-based reasoning (CBR) theory and Adaptive Web-based Educational Systems to response to the challenges of Bologna Process, based on the student learning style, goals and learning interests.

iDomus architecture is based on intelligent tutoring systems architecture, composed by the student, pedagogical, domain and interface modules. The student module has the mission to identify the student profile and is based on Honey-Alonso learning styles questionnaire (CHAEA), adapted and validated for the Portuguese language by Miranda (Miranda 2005). To identify the learning style of each student it was integrated in iDomus system the CHAEA questionnaire. The student when accesses the system is invited to complete the questionnaire.

The questionnaire consists of eighty questions enabling the identification of preferences for each style: activist, reflector, theorist and pragmatist.

The pedagogical module is based on Learning Design standards to define learning activities and the CBR theory to adapt learning activities to the student model.

The CBR retrieving method is based on Fuzzy logic, extracting the most similar cases based on the learning style and student profile, taking into consideration the interest and the complexity of each learning activity (Alves, 2008).

With Fuzzy approach it's possible to find similar cases of the current learning activity, extracting notes, forum posts and Web resources related to the activity. To enhance the learning interactivity, the system highlights parts of the content, based on the possibility of difficulties that match the present case.

The student uses the Learning Design Player integrated in the VLE to perform the learning activities (Fig. 4 - 1). When the student starts the activity the agent, using the information about the profile of the student, uses the CBR approach to find similar cases. The similarity is based on the profile of the student and previous experiences in that activity. Based on the similarity of cases the agent suggests the time to accomplish the learning activity (Fig. 4 - 2).

The agent has an active and passive mode. The active mode can be activated when the time to finish the activity is reached, then the agent gives support to the student presenting notes, forum messages and Web resources related to that activity (Fig. 4 - 4). The passive mode is activated when the student clicks on any note inserted on the page.

To improve the collaboration features of the environment, the student has the option to mark doubts inside contents by selecting the text and click on the appropriate button (Fig. 4- 3). The agent uses CBR to select the notes, discussion themes and Web resources related to that doubt. In the same toolbar has the option to insert notes on the page by selecting the text to insert the note.

The interface is very interactive and the student has the feeling that everything is dynamic. To provide this feature the system was developed using Ajax (Asynchronous Javascript And XML) and Web Services to provide the agent support without having to reload the entire page.

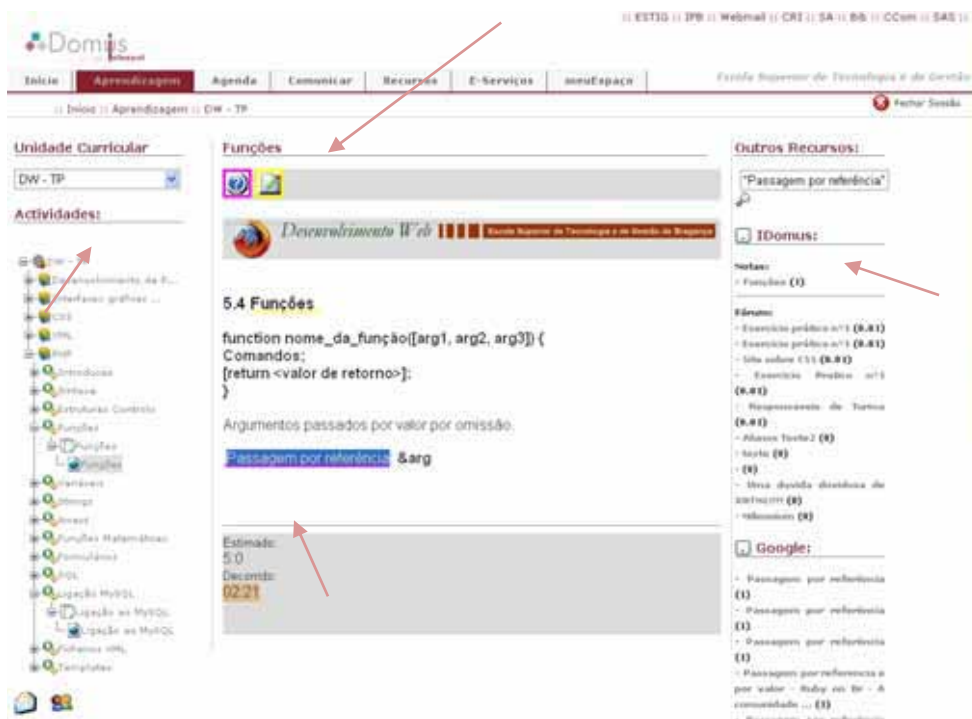


Fig. 4. iDomus system

This architecture based on CBR and adaptive hypermedia systems has the main goal to support the student on learning activities. The main advantage of this approach is the reuse of learning contents and contexts, increasing the knowledge of the system as the time passes.

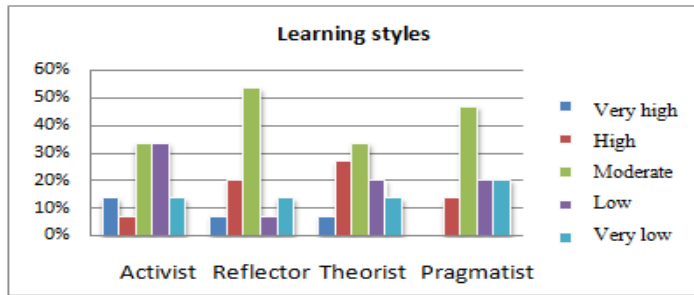
To evaluate the iDomus system it was made a case study in two different groups. One of Introduction to Computer Science, composed by 20 students, and other of Web Development, composed by 15 students. The number of styles identified is less than the number of users of the platform, because the answer to the questionnaire was voluntary and doesn't restrict the use of the iDomus system.

To identify the students' learning styles it was only considered the experimental group, which used the iDomus platform. The control group used a different platform without CBR and adaptive features.

The experimental group of Web Development had a smaller membership in response to the questionnaire than the group of Introduction to Computer Science.

The analysis of the results identifies a moderate preference for each style: active, reflective, theoretical and pragmatic. Only 7% of students had a very high preference for reflective style and 13% by the theoretical. There isn't any student with a very high preference to the pragmatic style. The moderate level is the predominant.

In the adaptation of learning context made by iDomus to each student learning style, shows that most of the students had a moderate preference, which implies a very narrow adaptation.



Graphic 1. Learning styles of research group

The iDomus system modulate the user behaviour based on the student learning style, but with a main moderated preference for each style most of the students had a standard view of the system. Only for students with a very high preference for the active style, iDomus had made an adaptation of the learning activities to explore the potential and students creativity. For students with a very high preference for the reflector and theorist styles, the system did an adaptation on forums, to improve reflection, and on the Chat to promote a direct discussion for activists.

In the survey the students recognize the importance of the contents organized in learning activities and the adaptation of the activities and contents to their learning needs. iDomus uses the CBR, adapting past cases to solve new problems, with characteristics of an advisor that alerts the student for all the events, coaching the student and coordinating the collaborative activities.

6. Conclusions and future research

The use of intelligent systems in education has several advantages in the support and personalization of e-learning. The adoption of artificial intelligence in education starts with Intelligent tutoring systems, which are typically used in computer-based training (CBT) and don't support the collaboration and cooperation. In this chapter it was proposed the adoption of Case-based reasoning and Adaptive Web-based Educational Systems to model student-centred Virtual Learning Environments.

Learning styles had become increasingly important in education with the lifelong learning paradigm that leads to new learning contexts, which are increasingly more heterogeneous. It's important to take into account the learning styles of each student to provide a more effective educational process.

The iDomus platform is a virtual learning environment that uses intelligent artificial methodologies like CBR and fuzzy logic to adapt learning activities to the student learning needs, based on difficulties and different learning styles.

The validation of iDomus was done through the data collection and two case studies, one in Introduction to Computer Science and other in Web Development.

Based on the results it can be concluded that the integration of collaborative and adaptive capabilities of Intelligent Tutoring Systems in Adaptive Hypermedia Systems, with

possibility to add notes to contents to share knowledge, is an important feature to improve the learning experience.

The organization of contents using learning activities was highlighted as very important by the students in the survey and the adoption of learning styles to model the user profile was considered important.

The iDomus supports the student in their learning activities, collaborative work, agenda management and shows several points of view of some subjects, suggesting Web resources to complement the student knowledge.

These capabilities can be adopted in several virtual learning environments to provide a more effective support in the learning process, going in the direction of the needs of knowledge based societies.

In terms of future work is proposed the improvement of the CBR adaptation features based on conversational case-based reasoning, where the user opinion in the adaptation process is considered as an important part to improve the accuracy of the results in future adaptations. On the contrary, open source virtual learning environments like Sakai and Moodle are adopted in the majority of universities, making it very difficult to integrate new systems like iDomus. The development of adaptive features to Sakai is a project that is been running at the University of Applied Sciences of Bragança in partnership with other institutions, to support Learning Design and CBR tutoring agents in Sakai 3.

7. References

- Aamodt, A., Plaza, E (1994). Case-based reasoning: Foundational issues, methodological variations, and system approaches. *Artificial Intelligence Communications*, 7(1):39(59)
- Ally M. (2004), *Designing Distributed Environments with Intelligent Software Agents*, Idea Group Publishing
- Alonso, C., et al (1999), *Los estilos de aprendizaje: Procedimientos de diagnostico y mejora* (4th ed), Ediciones Mensajero, Bilbao
- Alves, P., Amaral, L., Pires, J. (2008). Case-Based Reasoning Approach to Adaptive Web-Based Educational Systems, *ICALT '08: Proceedings of the 2008 Eighth IEEE International Conference on Advanced Learning Technologies*, pp. 260-261, IEEE Computer Society, Santander
- Brusilovsky, P. and Maybury, M.T (2002). From adaptive hypermedia to adaptive Web. *Communications of the ACM*, 45, 5, 31-33
- Burn, H., Caps, C. (1988). *Intelligent Tutoring Systems*. Lawrence Erlbaum Associates, Hillsdale, NJ
- de la Harpe, B., Kulski, M. and Radloff, A. (1999). How best to document the quality of our teaching and our students' learning? In K. Martin, N. Stanley and N. Davison (Eds), *Teaching in the Disciplines/ Learning in Context*, 108-113. *Proceedings of the 8th Annual Teaching Learning Forum*, The University of Western Australia, Perth: UWA.
- De Bra, P., Smits, D., Stash, N. (2006), *Creating and Delivering Adaptive Courses with AHA!*, *Proceedings of the first European Conference on Technology Enhanced Learning, EC-TEL 2006*, Springer LNCS 4227, pp. 21-33, Crete

- Dias, P. (2004). Comunidades de aprendizagem e formação online, *Nov@Formação, Revista Sobre a Formação a Distância & E-learning*, Inofor, pp. 14-17
- Figueiredo, A. e Afonso, A. (2005). Context and Learning: a philosophical framework, in A. Figueiredo e A. Afonso (eds) *Managing Learning in Virtual Settings: The Role of Context*, Hershey, PA, USA: Idea Group Publishing
- Gibbs, G. (1992). *Assessing more students*. Oxford: Oxford Brookes University.
- Goodman, B., Hitzeman, J., Linton, F., Ross, H. (2003) *Towards Intelligent Agents for Collaborative Learning: Recognizing the Role of Dialogue Participants*. In *Proc. of Artificial Intelligence in Education (AIED)*, IOS Press, Amsterdam
- Honey, P. and Mumford A. (1986). *A Manual of Learning Styles*, Peter Honey, Maidenhead
- Kearsley, G. P. (1987), *Artificial intelligence and education: Applications and methods*, Addison-Wesley
- Kolb, D. (1984). *Experiential Learning*, Prentice Hall
- Kolodner, J. (1993). *Case-based Reasoning*, Morgan Kaufman
- Lesgold, A., Katz, S., Greenberg, L., Hughes, E., Eggen, G. (1992). Extensions of Intelligent Tutoring Paradigms to Support Collaborative Learning. In S. Dijkstra, H. Krammer, J. van Merriënboer (Eds.), *Instructional Models in Computer-Based Learning Environments*. Berlin: Springer-Verlag, pp. 291-311
- Miranda, L. (2005), *Educação online: interacção e estilos de aprendizagem de alunos do ensino superior numa plataforma Web*, Tese de Doutoramento, Universidade do Minho
- Nwana, H. S. (1996), *Software agents: An overview*. *The Knowledge Engineering Review*, 11(3), 1-40
- Shaw, Erin; Johnson, W. Lewis; and Ganeshan, Rajaram (1999). "Pedagogical Agents on the Web." In *Proceedings of the Third International Conference on Autonomous Agents*. New York: ACM Press
- Sleeman, D., & Brown J. S., 1982, *Intelligent tutoring systems*. New York: Academic Press
- Wenger, E. (1987), *Artificial intelligence and tutoring systems: Computational and cognitive approaches to the communication of knowledge*. Los Altos, CA: Morgan Kaufman
- Yang, C. et al.(2001). Applying collision avoidance expert system to navigation training systems as an intelligent tutor. *Proceedings of IEA/AIE 14th International Conference, Budapest, Hungary*, pp. 941-947