Affective tutoring systems in a learning social network

Ramón Zatarain-Cabada* and María Lucía Barrón-Estrada

Instituto Tecnológico de Culiacán,
Juan de Dios Bátiz s/n, Col. Guadalupe,
Culiacán Sinaloa, 80220, México
E-mail: rzc777@hotmail.com
E-mail: rzatarain@itculiacan.edu.mx
E-mail: lbarron@itculiacan.edu.mx
E-mail: luciabarron@gmail.com
*Corresponding author

Abstract: Knowledge societies also named learning social networks allow interaction and collaboration between individuals (instructors and students), who share their connections under a scheme of learning communities around common learning interest. In this paper, we present an affective tutoring system inside a knowledge society implemented in a learning social network. We have designed a new architecture for an entire system that includes the social network with an educational approach, and a set of intelligent tutoring systems for mathematics learning which analyse and evaluate cognitive and affective aspects of the learners. The intelligent tutoring systems were developed based on different theories, concepts and technologies. In this paper, we present an affective tutoring system embedded in a social network which is used to improve poor student results in ENLACE test (National Assessment of Academic Achievement in Schools in Mexico). We also present results when applying the tutoring system to a group of students.

Keywords: intelligent tutoring systems; ITS; social networks; affective tutoring systems; mathematics learning.


Biographical notes: Ramón Zatarain-Cabada is Professor and Researcher of the Master of Computer Science at the Instituto Tecnológico de Culiacán in México. He received his Master of Science and PhD degrees in Computer Science from Florida Institute of Technology. He is a member of the National Research System in México, Level II. His main research interests include e-learning, m-learning and artificial intelligence in the education.

María Lucía Barrón-Estrada is Professor and Researcher of the Master of Computer Science at the Instituto Tecnológico de Culiacán, México. She holds a degree in Computer Science from the Instituto Tecnológico de Culiacán, MSc in Computer Science from the Instituto Tecnológico de Toluca and PhD in Computer Science from the Florida Institute of Technology. She is a member of the National System of Researchers in México, Level II. Her main research interests are mobile, web-based and hybrid learning. She also works on the implementation of authoring tools for intelligent tutoring systems and programming languages.
1 Introduction

Social networks (SN) have a great impact on the daily lives of many people. In Liccardi et al. (2007) defined SN as a structure of nodes that represent individual relationships (or organisations) among people of a certain domain. We can also say that a SN is a dynamic interaction which allows sharing different types of files, comments and topics (Calvo-Muñoz, 2009). There are several types of SN, which are distinguished according to the approach they have. For example, in the area of education SN has also become a success. Knowledge societies or learning social networks (LSNs) allow interaction and collaboration between instructors and students, who share their connections under a scheme of communities around common learning interest. The main benefit of using this new approach in education is collecting the information and ideas to create the store of the courses from the whole community of users (including students and instructors). Another benefit is taking advantage of technologies (wikis, blogs and social networking) that young learners are using in their spare time. Learnhub, Wiziq, and LectureShare are examples of LSNs or eLearning 2.0 applications. These LSNs provide an online education site for instructors and learners of all kinds. These users can create communities, share courses and lessons, have discussions, make quizzes, etc. However, learning material (courses, lessons, quizzes or tests) authored and used by the users in those LSNs does not provide the ability to recognise the student’s affective or emotional state, in addition to traditional cognitive state recognition.

Intelligent tutoring systems (ITS) are computer programmes that use a lot of resources to support teaching and learning process. ITS must incorporate techniques of artificial intelligence (AI) and education, with the aim of creating a flexible and interactive environment that considers the different cognitive styles of students (Stankov et al., 2011; Günel, 2010). ITS should play an important role in monitoring both the learning the student has built, as well as the identification of weaknesses, in order to find strategies that fit the student’s cognitive style.

The main contribution of this paper lies at the integration of AI with SLNs. In this work we present the architecture and the implementation of an affective and ITS embedded in a learning social network. Both elements, the ITS and the social network, is going to be used to improve poor Math results in the ENLACE test (National Assessment of Academic Achievement in Schools in Mexico). ENLACE is the standardised evaluation of the National Educational System, applied to students in Grades 1 to 9 in public and private schools. The results of ENLACE applied in early 2011 to 14 million children from third to ninth elementary level, reveals that more than nine million students have an ‘insufficient’ and ‘elemental’ level in learning mathematics (http://www.enlace.sep.gob.mx/). This test is in Spanish and measures learning in math, Spanish, and a third subject that changes every year.

This paper is organised as follows. In Section 2, we present a general architecture of Fermat. Section 3 gives information about the analysis and design of the social network. Section 4 explains how an ITS is structured. Section 5 will discuss some results. Section 6 presents related work and finally conclusions are presented in Section 7.
2 Fermat architecture

Learning social network Fermat has the basic functionalities in all SN, but its main feature is that it includes an ITS that offers the course content in a personalised style to users, as shown in Figure 1.

Users of the network are associated with personal, academic and affective information in a profile, which is obtained statically and dynamically. The static profile contains the initial information of the user (e.g., personal and academic information). The dynamic profile will be updated according to the user interaction within the network and the ITS, taking into account during this interaction, cognitive and emotional aspects. According to Kort et al. (2001), emotions are closely related to student learning, which in our point of view, represent a key factor to the student results.

Cognitive factors are obtained according to the history that we obtain from the results of examinations and exercises. Emotional factors are obtained by sensors that are monitoring the user’s emotions.

3 The analysis and design of Fermat

In the analysis phase we determine the objectives and requirements of the social network, which are fundamental to understanding the features needed by the user to interact and use the network.
These features provide a set of requirements that must have the network. To capture user requirements, use cases were created, which show how the user interacts with the system.

After having clear user requirements, we proceed to design the way they will be in the social network. For social network design we took into account four main topics: data model, architecture, interfaces and components.

The components of the social network as the editor and the browser, the user management, the learning objects, the collaboration of users in the network, and the adaptation of courses to a cognitive style are directly related to achieving one of the primary functions of a social network, which is to enhance collaborative learning using intelligent tutor system.

For the design of the interfaces we use the Mockup Builder tool (Nieters et al., 2007).

4 Fermat ITS

The ITS developed for the Fermat social network is composed of three components (Figure 2), which together are able to determine what the students know and how is their progress, adjusting to the needs of them (Stankov et al., 2011). The three components are:

1. expert (teacher) or domain module
2. student module
3. tutor or pedagogical module.

Figure 2 General architecture of the ITS

- **Expert module**: It is the one that contains the description of knowledge on the subject of a particular domain, providing knowledge of what is taught to the student, so he can gain the skills and concepts required for meaningful learning. A course in Fermat can be seen as a tree diagram containing chapters and in turn these are made by topics, as shown in Figure 3. The totality of all nodes in the tree represents the expert knowledge.
• **Student module:** This module is responsible for assessing the student performance to determine the cognitive abilities and reasoning skills. It provides the information about what a student knows. This module is central to the tutor module in the selection of the cognitive style that better suits the user. Fermat realises what the student’s knowledge is through a diagnostic test. The test results show what the student knows and what he needs to learn. The Fermat student module can be seen as a sub-tree of all knowledge possessed by the expert in the domain, as shown in the left part of Figure 3. The representation is based on a model called ‘Overlay’, where the student’s knowledge is a subset of the expert knowledge. As the student uses the ITS he expands this subset (Günel, 2010).

• **Tutor module:** This module represents the fundamental strategies for teaching the learning contents with Fermat. It is responsible for selecting the appropriate learning method and provides assistance to the student. For example, the tutor must know how to respond when the student cannot answer a question. In Fermat, The tutor module was implemented based on ACT-R theory of cognition (Anderson et al., 1990).

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Figure 3  Structure of Fermat courses

On the other hand, a module that integrates the tutor module recognises the emotional states of students. Emotions are detected by expression of the face and by voice. The method used for the detection of visual emotions is based on Ekman’s theory (Ekman and Oster, 1979), which recognises ten emotions: anger, disgust, fear, happiness, sadness, surprise, well, bored, tired, and neutral. To determine the emotion, we first take the image which is transformed to a more basic form (Ioanna-Ourania and Tsikrintzis, 2010). Based on this picture we get the feature points that minimise the set of input data to the neural network. We use a Kohonen NEURAL network with $20 \times 20$ input neurons and two output ones representing the emotion.
For the detection of emotions in the voice, this is captured primarily through the computer microphone and then is normalised. Then we apply the technique to characterise components analysis (PCA) to the signal representing the voice. After using the SFFS method (Pudil et al., 1994) we obtain an optimal set of features that will feed the neural network.

In Figure 4, we can see how we integrate the visual and sound emotions using a neural network. Having recognised the emotion, this is sent to the intelligent tutor to respond based on the emotion (Du Boulay, 2011).

**Figure 4** Emotion recognition (see online version for colours)

5 Fermat testing

Fermat social network along with its ITS was evaluated by a group of children from third grade. There were 72 children from public and private schools who tested the tool and the tutoring system. Before the evaluation we offered a small introduction to the social network environment and the tutoring system interface. Figure 5 shows three interfaces of the social network (starting a session, making friends, and editing a test) and one interface of the tutoring system for solving a math exercise.

We evaluated the subject of multiplication. We applied a test with different exercises before and after the students used Fermat. Figure 6 shows some students from public and private schools using the tools.

Table 1 shows the results of a random sample of ten students who took a test before and after using Fermat. We can see from the results a good improvement in most students (more in students with lower initial grades) using one of the two teaching methods for multiplication: traditional and lattice.
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Figure 5  Four interfaces of the social network and the tutoring system (see online version for colours)

![Image of interfaces]

Figure 6  Children testing Fermat in public and private schools (see online version for colours)

![Image of children testing]

Table 1  Results, course level, and learning method for ten students

<table>
<thead>
<tr>
<th>Student</th>
<th>Initial grade</th>
<th>Final grade</th>
<th>Improvement %</th>
<th>Course level</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.74</td>
<td>7.89</td>
<td>31.5</td>
<td>Difficult</td>
<td>Traditional</td>
</tr>
<tr>
<td>2</td>
<td>3.68</td>
<td>4.21</td>
<td>5.3</td>
<td>Normal</td>
<td>Lattice</td>
</tr>
<tr>
<td>3</td>
<td>3.68</td>
<td>7.89</td>
<td>42.1</td>
<td>Difficult</td>
<td>Lattice</td>
</tr>
<tr>
<td>4</td>
<td>7.89</td>
<td>8.42</td>
<td>5.3</td>
<td>Difficult</td>
<td>Traditional</td>
</tr>
<tr>
<td>5</td>
<td>7.37</td>
<td>8.42</td>
<td>10.5</td>
<td>Difficult</td>
<td>Traditional</td>
</tr>
<tr>
<td>6</td>
<td>10.00</td>
<td>10.00</td>
<td>0</td>
<td>Difficult</td>
<td>Traditional</td>
</tr>
<tr>
<td>7</td>
<td>6.84</td>
<td>8.42</td>
<td>15.8</td>
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<td>Traditional</td>
</tr>
<tr>
<td>8</td>
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<td>8.42</td>
<td>0</td>
<td>Difficult</td>
<td>Lattice</td>
</tr>
<tr>
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<td>9.47</td>
<td>10.5</td>
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<td>Traditional</td>
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<tr>
<td>Total %</td>
<td>6.78</td>
<td>8.12</td>
<td>13.4</td>
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</tr>
</tbody>
</table>
6 Related work

The boom of SN within the web has led to the emergence of social networking sites aimed at the education field. Ivanova (2008) presents an analysis of seven systems of eLearning 2.0: EctoLearning, Edu 2.0, 2.0 eLearning Community, LearnHub, LectureShare, Nfomedia, and Tutorom (Eduslide). Some of them can be commonly identified as social learning networks according to their characteristics. EctoLearning hosts libraries of knowledge that can be explored, imported, traded, qualified, modified or shared. In Edu 2.0 we can simulate the operation of an educational institution through the functionality provided by the system. WiZiQ is completely free online software, which allows users to interact through text, audio and video with other participants in a shared virtual space. The space contains a whiteboard with powerful drawing tools, where users move between different boards and download PowerPoint presentations to show one or more users.

All these systems have multiple functionalities to enable an author to create, deploy, share and evaluate different types of learning objects. However, learning objects deployed to teach and evaluate all students are the same. This means that there is no recognition of individuality in the way students learn and are evaluated.

7 Conclusions

The social network along with the ITS was implemented using different software tools and programming languages. The presentation (main interfaces) layer of the social network was implemented with CCS3, HTML 5 and Javascript. For the logical layer (ITS modules and social network functionalities) we use Java and JSP. For the database layer we use XML and MySQL.

SN is a good tool where users can find a meeting space, making promote attitudes of cooperation. Adding to Social Network an ITS helped the teacher with the learning process for students to gain meaningful learning. The results actually show that an Intelligent Social Network for Learning Mathematics can assist traditional or formal education.

References

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