Collaborative Groups in a Medical Learning Environment

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ABSTRACT. This paper addresses collaborative learning in the medical domain, focusing on the evaluation of a component specially devised to promote collaborative learning using the AMPLIA system. AMPLIA is an intelligent multi-agent environment that supports diagnostic reasoning and the modeling of diagnostic hypotheses in the medical domain. Recently it has been extended with a new component providing aid on workgroup formation. Workgroups are built considering the individual aspects of students as the learning style, performance, affective state, personality traits, and also group aspects such as acceptance and social skills. This paper presents and discusses the results of an experiment evaluating the quality of workgroups that was composed according to suggestions provided by the system.

KEYWORDS: collaborative learning systems, group processes, medical education, problem-based learning.
1. Introduction

This paper describes the features of group suggestion within the AMPLIA [27] learning environment. The main functions of medical learning environments (explanation, education, and diagnostic) are traditionally implemented as one-way mechanisms. This means that the system has total control over interactions. AMPLIA attempts to deal with them as bilateral processes, which means that a diagnostic model is built collaboratively. AMPLIA is a Multi-Agent System (MAS) designed to work as an extra resource for the education of medical students. It supports the development of probabilistic diagnostic reasoning and the modelling of diagnostic hypotheses. AMPLIA is a software application designed and developed to model aspects of individuals, promoting collaboration. For this purpose, it has a Bayesian Network editor that can be considered an intelligent e-collaborative technological tool. The system editor has been recently extended to provide the creation of virtual workgroups in order to solve tasks in a collaborative way.

Clinical reasoning is the way an expert resolves a clinical case – from a possible diagnostic hypothesis, the professional looks for evidence that confirms or rejects the hypothesis [11]. This type of reasoning is named top-down, because it starts from the diagnosis in order to find evidence, and this way the evidence justifies the diagnosis. A medical student, however, takes the opposite approach; he searches for a diagnosis that justifies the evidence because he does not have a diagnostic hypothesis. This reasoning is called bottom-up, starting from an evidence to achieve a diagnosis.
The technological focus of our research is to design and develop an ITS (Intelligent Tutoring Systems) using pedagogical agents and MAS as software engineering tools. By using the agent’s technology to design, represent, and execute the student model, it becomes a pro-active model that becomes similar to a real student while being modeled. However, as agent and MAS architectures are implementation oriented, just providing schemas to build agents and systems, they are inadequate as tools for analysis. In the case of pedagogical agents, it is not easy to respect the pedagogical theoretical foundations that are the basis for such agents while under construction.

Following these principles, AMPLIA was built to explore pedagogical strategies, cognitive student models, and interoperability methods for ITS integration. The function of AMPLIA is to support the development of diagnostic reasoning and hypotheses modeling in the medical area by using probabilistic mechanisms for knowledge representation. Student activities comprise the representation of a diagnosis for a clinical case in a Bayesian Network (BN) model. The student’s network is compared to the expert’s network in the domain stored within the environment. Differences between networks are managed through pedagogical strategies based on the constructivist theory. BN’s have been widely employed in the modeling of uncertain knowledge domains, such as medical diagnosis. Uncertainty is represented through probabilities and the basic inference is the probabilistic reasoning based on the hypothesis that physician implicitly carries out a probabilistic reasoning during diagnose. This is supported by reviews on case studies in the medical field [12].
Advances in ITS made use of architectures based on agent’s society [15] [10] [17]. Group dynamic has also been addressed through researches and in different areas. The multi-agent approach is considered suitable to model the group formation and coordination problem. In addition, it has proved a very adequate potential in the development of teaching systems due to the fact that the nature of teaching-learning interaction is easily solved in a collaborative manner.

In a real classroom, students form workgroups considering mainly the affinity that exists between them. Sometimes workgroups are composed taking into account geographic proximity (mainly for Distance Learning), and these groups do not often present a good performance in learning activities. Our research question is: Can valuable group suggestions emerge from an integrated analysis of cognitive individual and collective student models?

The following section summarizes some concepts related with collaborative learning. An overview of software specifically developed to support learning in the medical domain is presented in section 3. Section 4 describes the group model, recently integrated in AMPLIA. Section 5 presents and discusses an experiment assessing the quality of the collaborative component. Finally, the paper ends with conclusions and future research.

2. Collaborative learning

In the learning and teaching area, cooperation can be seen as a special sort of collaboration. It is known that Collaboration is a type of interaction where individuals are responsible for their actions, which include learning and considering the abilities
Collaborative learning is a method of teaching and learning in which students explore a significant question or create a meaningful project. Two examples of collaborative learning are 1) group of students discussing a lecture and writing a collaborative text (e.g., wiki) based on main lecture topics, and 2) students from different universities working together in a shared assignment on the Internet such as the interface design of an educational software. Cooperative learning is a specific kind of collaborative learning where students work together in small groups on a structured activity. The students are individually responsible for their work, and the work of the group, which becomes accountable, is also assessed. Cooperative groups work face-to-face and learn to function as a team.

Collaborative Learning Environments (CLE’s) are systems particularly developed to support the participation, collaboration and cooperation of users sharing a common objective. In a CLE, the learner has to be active, manipulating objects, integrating new concepts, building models, and collaborating with each other. Additionally, it is necessary to be reflective and critical.

Learning environments should provide students with a sense of challenge and safety. The groups should be small enough to allow ample contribution while tasks should be clearly defined. Although several authors use the cooperative learning concept as defined by Piaget [20], our research follows the definition presented by Dillenbourg et al. [8]. Thus, collaboration here is seen as a joint work to achieve a common goal without the division of tasks and responsibilities.

The CLE design should also take into account social factors [24] [5]. Vassileva and Cao et al. concluded the importance of considering sociological aspects of
collaboration in order to discover and describe existent relationships among people and organizational structures, and incentives for collaborative action. Hence, learning environments may be able to detect and solve conflicts, provide help to task performance, and also motivate learning and collaboration. In addition, Vassileva discusses strategies and techniques to motivate collaboration among students. Cheng and Vassileva [6] propose a motivation strategy for a user’s participation based on persuasion theories on social psychology. For Cao et al. [5], the goal is to find out how people develop attitudes of liking or disliking other people when they interact in a CSCW (Computer Supported Cooperative Work) environment and in a collaborative-competitive situation. The ideas presented in [5] [24] consider social aspects in order to motivate collaboration. One of these aspects is the rewarding mechanism which aims to encourage users to contribute in online communities. In our research, the collaboration model also considers such social issues. More precisely, our research discusses on how students change their attitudes towards others and how the design of the environment influences the emergent social group. Prada and Paiva [22] developed a model that supports the dynamics of a group of synthetic agents inspired by theories of group dynamics developed in human social psychological sciences. They regarded different types of interactions that may occur in the group.

3. Computer-supported learning in medicine

The advent of computers usage as well as the constant development in the capacities of new technologies has brought a broad vision over the possibilities in using computers to support learning and training. Medical education is not an exception and during the last decade several systems for support in the learning of
medicine have been proposed. These approaches are mainly concerned with collaborative learning, problem-based learning, and computer based simulations [14]. According to Ward et al [26], communication and information technology (CIT) has affected learning in all domains while medical education has unique aspects and learning takes place during clinical concern. In addition, it offers opportunities to test learning methods that are not used in other contexts. Moreover, CIT is expected to become an integral component in the medical knowledge domain. We emphasize on how CIT can be used to support learning and teaching in medicine, and discuss on how the development of an all pervasive, high-speed information and knowledge network could affect the traditional medical curriculum.

Besides AMPLIA, other learning environments have also been expressly developed for medical education. A summarized overview of the main features of systems related to AMPLIA is shown below. A Bayesian Network-based appraisal model was used in Conati’s work to deduce a student’s emotional state based on their actions [7]. The probabilistic approach is also used in the COMET System [23], a collaborative intelligent tutoring system for medical problem-based learning. The system uses Bayesian Networks to model individual student knowledge and activity, as well as that of the group (users connected in the system). It incorporates a multi-model interface that integrates text and graphics to provide a communication channel between the students and the system, as well as among students in the group. COMET gives tutoring hints in order to avoid students from getting lost. Medicus is a simple tutorial system that does not include collaboration aspects. It supports a single user interacting with the system and uses Bayesian Networks to model knowledge [9].
Most of these environments use knowledge-based models. Moreover, the adopted strategies consider the interaction between the user and the system while group interactions or group models were ignored.

AMPLIA innovates by including a student model considering cognitive, social, and affective states [3]. This model allows the evaluation of individual student profiles and then proposes the creation of work groups. We envisage the application of the system to promote the collaboration of several students solving together a clinical case through the web. Additionally, AMPLIA considers self-confidence in the sense that each group announces the confidence level on the proposed solution. Therefore, conveyed by this confidence level, the tutor adjusts the most adequate strategy to guide students to the right solution. The strategies adopted in related systems consider user/system interaction, and not group interaction. All these features contribute to improve the CLE design.

AMPLIA is composed of 4 different agents. The Domain and Learner Agents are modeled using Bayesian Networks, which have been widely employed to model uncertain domains such as medicine. The Mediator Agent is modeled using Influence Diagrams while the ComServer Agent coordinates the communication activities among other AMPLIA agents.

The Learner, Mediator and Domain Agents are cognitive agents, i.e. they have knowledge on how to solve certain problems as they have the ability to reason and make decisions on actions involved in teaching and learning activities. The main idea that has guided AMPLIA’s design has been the need in offering an open environment in which a student can build a graphical model to represent his diagnostic hypothesis.
for a clinical case using BNs. Students can build their diagnostic hypothesis by themselves or by collaborating in a group with other students. The student’s or group’s network is then compared to that of an expert in the area, and the differences among the networks are monitored by the Mediator Agent, which uses pedagogic strategies based on the constructivist model in order to build BNs with a satisfactory solution.

4. Group model

This section details the AMPLIA’s collaborative editor, the application where the Social Agent watches and interacts with students. The Social Agent reasoning, modeled with Bayesian Networks, is presented in subsection 4.2. Finally, subsection 4.3 details the strategies used by the Social Agent in order to suggest collaborative groups.

4.1. AMPLIA’s Collaborative Editor

The first version of AMPLIA’s editor was not collaborative and allowed only one student to work with the system at a time [25]. According to learning theories in medicine based on problem-based learning [19], the editor was extended to permit several students to operate it simultaneously in a collaborative fashion. Besides the online editing support (see Figure 1), the system was provided with a group model designed through the Social Agent, whose main goal was to motivate collaboration and improve group activity. As depicted in Figure 1, BN editing is possible through buttons found available in the toolbars. There are menu options to insert nodes, arcs and probabilities.
Figure 1 shows part of the BN that is under development by a group of students. In the smaller window, on the right, we can see the Node’s Properties Editor where the CPT (Conditional Probability Table) associated with variables (nodes) can be updated.

At the bottom of the screen we can find collaborative editing options, including online users’ listing and a chat tool.

4.2. The Social Agent

The main goal of the Social Agent is to create student workgroups to solve tasks in a collaborative manner [2] in the AMPLIA system. The Social Agent is based on social psychology ideas (to support social aspects) and affective states of the involved students. Interaction is stimulated by recommending the students to join workgroups
in order to provide and receive help from other students, and the knowledge of the Social Agent is implemented with Probabilistic Networks. In the AMPLIA, each user builds their own BN for a specific pathology using the collaborative graphic editor. During this task, the Social Agent recommends other students that can participate in the BNs development.

![Decision network of the Social Agent](image)

**Figure 2 – Decision network of the Social Agent**

The student’s feature set is based on social and collaborative theories. The information collected to define a suitable recommendation includes: Social Profile, Acceptance Degree, Affective State (Emotion for Self and Emotion for Outcome), Learning Style, Personality Traits, Credibility, and Student Action Outcome (Performance). The Social Profile and the Acceptance Degree were detailed in [3]. The socio-affective agent selects the action that maximizes this value when deciding on how to act. The influence between nodes is shown in Figure 2. This network is made from a decision node (rectangle), a utility node (diamond) and uncertainty nodes (oval).
The model of Conati [7], based on the OCC Model [18] is used to infer emotion. The affective states can be regarded as an emotion manifestation at a specific time. Conati modeled a Bayesian Network to infer emotions and consider the student’s personality, goals, and interaction patterns to attain emotions [27] [7], thus obtaining state values for *PersonalityTraits* and *AffectiveState* nodes.

The states of *Credibility* and *Student Action Outcome* nodes are informed by AMPLIA’s agents. The *Student Action Outcome* node represents a possible classification for the student’s BN model, which may take the following values: *Unfeasible; Incorrect; Incomplete; Feasible,* and *Complete.* The decision node *Plan* is responsible for recommendation, which is a suitable group for a student. Such plans are selected from a function of utility (node *Utility*). The *Plan* node states are *recommend* and *do not recommend* a student to join a workgroup. The *Utility* node selects the student that maximizes the *recommend* value.

### 4.3. Strategies for group proposal

The Social Agent uses different strategies to suggest a particular student to a workgroup. Students can join different groups whereas each group can work with different study cases, knowing that within medicine the teaching approach relies mostly on problem-based learning.

Participation in a group depends on the approval of the student by the members of the group. When the student is invited to join the group, he may also accept or decline the offer. When the student refuses to participate in a workgroup, the system may
inquire on the reason of declination by presenting him with the following alternatives:
(i.) I do not have interest in this subject; (ii.) I am temporarily unavailable; and, (iii.) I
do not have interest in interacting with this group. The actions of the users are stored
in the student model. This model is employed when the Social Agent looks for
students to join a workgroup. The groups are dynamically formed, based on the task
that is carried out. Students can participate in several groups simultaneously according
to their interest. Each group must have at least one student in the leadership role.

When a student moves actively in the learning environment (interacting and
making contributions to the development of BNs), the Social Agent records this
information and verifies if he was the most active collaborator in the network
construction. This can be reinforced when the student had his work modified the less
number of times.

The Social Agent also tries to create groups with democratic profiles or sharing
roles where all team members are capable to lead the team. This occurs when the
responsibility for the operation of the team is shared (role-sharing), leading to shared
accountability and competencies. The leader should focus on the process and keep the
team functioning within a problem-solving process.

When students openly share the leadership or facilitator role, they are more likely
to be attentive to team maintenance issues when they reassume a certain position. In
this manner they can get to know better the team leader’s responsibilities [19].

Some strategies proposed by [4] can be useful to improve learning in groups such
as: work at getting good feedback, get silent members involved, confront problems,
vary the leadership style as needed, work at increasing self-disclosure, summarize and review your learning from group experiences (analyze the data to discover why the group was more or less effective and provide final feedback to members in their contribution), and celebrate the group's accomplishments.

The groups must also be formed by students with different levels of performance. For instance, considering that we have six people that include students with performance categorized as excellent, average and regular, it is then best to join two classmates of each level.

5. Experiments and Results

In the following we start by presenting an experiment and, afterwards, we show and comment the obtained results.

5.1. Description of the experiment

This research was developed based on focused questionnaires, which measures students’ behavior and opinions, and qualitative methods (interpretation of the observations and identification of the intensity or scale as a concept manifests itself). This method was adopted because of the complex nature of the problem under analysis, which involves the dynamic process experienced by social groups. Like most any scientific research, it was divided into three stages: planning, data collection and analysis of information. In all three stages we employed quantitative and qualitative techniques.
We conducted an experiment with AMPLIA involving a class of seventeen undergraduate medical students. All students were at the first period of graduation and, therefore, they have not seen each other for a long time. This experiment had the intention to assess:

1. preferences regarding the type of learning (individual against collaborative),
2. performance of the groups that were composed spontaneously or proposed by AMPLIA, and
3. quality of group suggestions.

Although the participation of students in practical experiments has not been high, a quantitative analysis was also important to verify relationships between variables in the model and the result of the actions of the students. The questionnaires were previously developed with the help of an expert in statistics in order to define the studied problem and allow the identification of case representatives (or not) in the individual and group level. Questionnaires were designed in order to observe the characteristics of the research in the proposed context and to analyze data relations and discoveries.

The object of research is the evaluation suggestion on working groups through the analysis in an individual model of student interaction and the resources of the AMPLIA environment. Selected techniques for the development of this research are: literature search, extensive direct observation (questionnaires), and intensive direct observation (observation and systematic observation in a laboratory).

The methodology applied to this research began with a bibliographic research, followed by systematic observation, which is a structured and planned technique. A
laboratory observation was conducted in order to discern students’ actions. Questionnaires are rich research instruments, but they may present some inconsistencies in relation to survey understanding. To minimize such inconsistency, participants in workshops (volunteer students) were oriented during the process of questionnaire completion.

The experiment was conducted in two designs. In each one the class was organized in six groups of students. In the first step, the students composed their own groups spontaneously. Then the students were rearranged in groups suggested by the AMPLIA system.

First of all, the AMPLIA environment was presented to the students in order to clarify the use of Bayesian Networks in the construction of diagnostic hypotheses. It is important to highlight that the class was unaware of BN concepts. The group of students built a BN (using the AMPLIA BN editor) to prove a diagnostic hypothesis. All groups worked in the same subject.

The six groups were then rearranged according to the suggestion by AMPLIA’s Social Agent, and each group alike solved a new diagnostic problem. In the end, the students answered two questionnaires. One assessed the use of AMPLIA as a pedagogical resource, while the other aimed at analyzing the performance of the groups composed by AMPLIA.

5.2. Results

The first assessment involved the evaluation of preferences and effectiveness regarding the type of learning. Concerning the collaboration between colleagues, the
students showed that most of them approved the group dynamic as an alternative to individual learning (Table 1). In fact, the majority of 94.1% of students affirmed that learning improves when they work in small groups. The same percentage also affirmed to be able to learn better during group activity, while some 5.9% stated that they were self-conscious during group interaction and considered that being with a group did not help the learning function.

Table 1 – Preference regarding the type of learning

<table>
<thead>
<tr>
<th>Dynamic</th>
<th>Student’s choice</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individually</td>
<td>1</td>
<td>5,9%</td>
</tr>
<tr>
<td>In a group</td>
<td>16</td>
<td>94,1%</td>
</tr>
</tbody>
</table>

More specifically, the students approved the collaborative way of work (Table 2). Only 5.9% of the students commented that group dynamic does not improve learning. A 58.8% of them affirmed that working in groups improve learning, while 35.3% corroborated that workgroups definitely improve learning. The mode and the median were coincident with the option “Probably Yes”.

Table 2 – Effectiveness of learning styles

<table>
<thead>
<tr>
<th>Working in groups helps your learning?</th>
<th>Student’s choice</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitely not</td>
<td>0</td>
<td>0,0%</td>
</tr>
<tr>
<td>Probably not</td>
<td>1</td>
<td>5,9%</td>
</tr>
<tr>
<td>I’m not sure</td>
<td>0</td>
<td>0,0%</td>
</tr>
<tr>
<td>Probably Yes</td>
<td>10</td>
<td>58,8%</td>
</tr>
<tr>
<td>Definitely Yes</td>
<td>6</td>
<td>35,3%</td>
</tr>
</tbody>
</table>
Concerning the evaluation of preference between groups that were spontaneously composed or proposed by AMPLIA, 82.4% of the students preferred working with groups selected by themselves against the 17.6% that favored the groups composed by the AMPLIA system (Table 3). The mode and the median coincided with the option “With a group I can choose”, revealing a preference to work with acquaintances.

<table>
<thead>
<tr>
<th>How did you prefer to learn?</th>
<th>Student’s choice</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individually</td>
<td>0</td>
<td>0,0%</td>
</tr>
<tr>
<td>With a group I can choose</td>
<td>14</td>
<td>82,4%</td>
</tr>
<tr>
<td>With a group proposed by the system</td>
<td>3</td>
<td>17,6%</td>
</tr>
</tbody>
</table>

On the other hand, 100% of the students asserted that they did like the groups suggested by the Social Agent and that they would work again with that same group formation.

When asked about group performance (Table 4), 58.8% of the students pointed out that both groups (spontaneously composed and system proposed) had a similar performance.

<table>
<thead>
<tr>
<th>Strategy that shows better performance</th>
<th>Student’s choice</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spontaneously composed was much better</td>
<td>4</td>
<td>23,5%</td>
</tr>
<tr>
<td>Composed by the Social Agent was better</td>
<td>1</td>
<td>5,9%</td>
</tr>
<tr>
<td>Spontaneously composed was slightly better</td>
<td>2</td>
<td>11,8%</td>
</tr>
<tr>
<td>Both groups performed well</td>
<td>10</td>
<td>58,8%</td>
</tr>
</tbody>
</table>
The mode and the median were coincident with the option “Both groups performed well”. Only a single student affirmed that the group proposed by the system was much better, while 35.3% considered that the spontaneously formed group performed better (much better and slightly better).

When asked about the quality of the system’s group suggestion (Table 5), 52.9% of the students affirmed that probably the system’s suggestion can help the choice between available groups. A 11.8% of them corroborated that the system’s suggestion definitely helps their choice, meaning that 64.7% found the suggestions helpful. Only 23.6% thought that the group suggestion did not help them. The mode and the median corresponded with the option “Probably Yes”, thus revealing the helpfulness of the produced group suggestions.

<table>
<thead>
<tr>
<th>Group suggestion helps the choice between available groups?</th>
<th>Student’s choice</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitely not</td>
<td>2</td>
<td>11.8%</td>
</tr>
<tr>
<td>Probably not</td>
<td>2</td>
<td>11.8%</td>
</tr>
<tr>
<td>I’m not sure</td>
<td>2</td>
<td>11.8%</td>
</tr>
<tr>
<td>Probably Yes</td>
<td>9</td>
<td>52.9%</td>
</tr>
<tr>
<td>Definitely Yes</td>
<td>2</td>
<td>11.8%</td>
</tr>
</tbody>
</table>

Before the completion of this experiment, three others were carried out with a reduced number of students. It was observed that in all experiments the results were similar, i.e., the experiments led to conclusion that the students preferred to work in a collaborative way.

In short, all the students involved in this experiment affirmed that they would work again with the group proposed by the system. This reveals that, although most of the
students preferred to work with people they already know (Table 3), the system is able to produce a satisfactory distribution of students among groups. Concerning the performance of the groups, the majority declared that both groups were equivalent. The system produced suggestions that aided people in choosing a group. In addition, it must be mentioned that system-proposed groups obtained better solutions to the problem. Nevertheless, we can not conclude that better performance was due to a better quality of the groups, as it happened in the second step when the students had more experience in solving the diagnostics.

5.3. Sociograms

Additionally to the above described experiment, sociograms were also used to evaluate students’ social acceptance. Sociograms are graphical representations capable of identifying popular or isolated students in a group. This approach was proposed by [16]. Sociograms are also an efficient tool to assess group cohesion. Cohesion is the attraction that a group has with its members, i.e., members care to participate, resisting in the idea of leaving it. Group cohesion can be measured by the amount of times students choose the same colleagues to interact. According to [13], cohesive groups have high productivity because group members establish a behavior of solidarity and loyalty with their group.

Due to the small participation of students in this experimental step, it was not possible to obtain precise conclusions on which students were socially cut off or more popular. However, the sociograms could give an idea of the students’ choice and
behavior in their groups. In the future this tool will be used by the Social Agent in order to suggest strategies when it concerns the involvement of isolated students.

6. Conclusions and future perspectives

AMPLIA is a tutoring system that supports medical students’ clinical reasoning. The editor allows the creation of virtual workgroups to solve tasks in a collaborative way. In addition, the AMPLIA environment contributes in the CLE research area because it considers cognitive, affective and social states in the student’s model. We aim at reducing the involvement of teachers, giving more autonomy to students.

Boff and Flores [1] discuss previous experiments with AMPLIA. The pedagogical impact was evaluated in 2005, by an experiment assessment on how AMPLIA can aid students from the teacher’s point of view and also from the student’s opinion. This study also permitted to conclude that students are mainly concerned with learning to produce correct diagnoses and being confident in their diagnoses. In 2006, the pedagogical methodology used by AMPLIA and its potential use in Medical Education were evaluated through a major experiment involving 62 people: teachers along with graduate and undergraduate students. Thus, a new collaborative feature of the system is assessed.

The Social Agent model was designed to provide student autonomy by using Bayesian Networks and probabilistic knowledge reasoning. The Social Agent model supports collaborative learning by stimulating interactions between students through the chat tool. This stimulation is directed by considering students individual profiles,
such as personality traits, learning style, affective state, performance, social profile, and social skills.

The tutor recommendation mechanism explores the social dimension through the analysis of emotional states and the social behavior of the users. In this direction, we aim to contribute in the design of learning environments centered in the student’s features and collaborative learning.

By now the system considers student profiles, analyses them and proposes group formation using the Social Agent. Then each group is assigned to a given diagnose problem and builds the corresponding diagnose network. For the tutor, each group assumes the role of an individual learner. The group is given space and time to discuss their options and the solution is built through the collaboration of group members. The tutor therefore evaluates the final group solution.

The experiment presented here is a starting point revealing that Social Agent reasoning can be used to suggest groups with good performance. In fact, the results are rather promising as the majority of the students, despite preferring to work in groups with people they already know, confirmed that groups proposed by the system had a similar performance or even better. Moreover, each student would work again with the AMPLIA proposed group, which means that the group proposals were adequate. These results validate our research question as valuable group suggestions emerged throughout an analysis of individual and collective cognitive student models.

AMPLIA is being continuously extended. In the near future, the system will be available to use on a Local Area Network (LAN), and a Web version is predicted.
Communication between agents on a different Web was facilitated by an ontology allowing an exchange on Bayesian knowledge. The availability of the chat tool promotes on-line collaboration between people working apart. Thus, the system is envisaged to be used by students that seek collaboration with unknown people on the Web.

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