Analysing Participant's Interactions in Collaborative Learning Environments

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Abstract

Collaborative learning can be motivated via environments that provide tools for communication, and discussion. In such environments, both students and instructors need online support in order to produce useful interactions. In this paper we discuss a novel method to analyse participant's interactions in Collaborative Learning Environments. We also propose an argumentation model to organise the group interaction and store the information in a multidimensional structure, which will be explored using analytical queries. An agent society receives information from the Collaborative Environment, reasons over it, and sends the results to the multidimensional structure. The results of this process generate the Learning Interaction Memory, which can be used by teachers to assess the learning progress and learners to evaluate their own progress.

Keywords: Collaborative Systems, CSCL, Context, Argumentation Models, Collaborative Learning

1. Introduction

There are several proposals of Internet-based learning tools (e.g. [16, 2]) that provide a wide variety of resources to learners, such as: information exchanging, non-linear navigation on learning material, discussion rooms and other communication tools (e.g., forums, blackboards, chats and video conferences). Despite the fact that these resources are important to learning processes, most current systems do not provide any intelligent support for students. For instance, these learning environments do not suggest better use of their tools so that learners can improve their knowledge and reflect about it [19, 4]. Such support is often given by teachers or human tutors during pre-defined times, and usually in response to explicit student requests. However, it is also the case that teachers generally do not have enough information to decide when is the best moment to interact with students, or to evaluate their learning process [23].

One of the ways of improving teacher-student relationship in virtual classrooms is to provide to the teacher information about the students' learning styles, progress and common doubts. Such information can be used to support learner reflection and can be acquired through the evaluation and diagnosis of interactions that occur among students and/or students and teacher. Hence, analysing the interactions will allow actions such as: (1) finding out both the most difficult and most interesting subjects for a specific student or group of students; (2) following the learning curve of students, finding the quicker learners in each subject, so that they can be used as peer tutors for students in trouble; (3) detecting apathetic students who need to be motivated.

However, evaluation, organisation, storage and management of information related to the interactions that occur in collaborative learning environments are complex tasks. Information can change at each new interaction with the collaborative environment. Furthermore, information is also context dependent (for example, access time, user's knowledge level and the role that an user was playing at the moment of the interaction are important for understand the ongoing discussion). In point of fact, learning always takes place in dynamic environments, characterised by a collection of relevant conditions and surrounding influences that make a situation unique and comprehensive [16].

This multidimensional aspect of interactions has motivated the use of data warehouses [22] in our project to store the content of such interactions. Storing this information into a multidimensional structure enables the system to analyse the interaction through On-Line Analytical Processing (OLAP) [20], where the interactions can be explored in different dimensions (e.g. subject, student knowledge level, etc) and levels of detail.

In order to be able to store the interactions for further analysis, we need to structure them, with the help of a data model. This generates what we call the Learning Interaction Memory (LIM). To model the LIM, we propose an extension of the IBIS (Issue Based Information System) argumentation model [11] to support learning interactions. And all these elements (argumentation model, set of results of the analytical queries etc) will be manipulated by an agent-based architecture.

Due to our use of argumentation models to organise information changed in learning environments, our work can be inserted in the Computer Supported Collaborative Argumentation (CSCA) area [13]. CSCA is an increasingly popular area of research, whereby networked computer-based tools are used to support the argumentation process. The key technologies attempt to achieve knowledge transformation (as opposed to simple representation or retrieval) by structuring discussions to graphically indicate agreements, disagreements etc. CSCA embeds the advantage to eliminate social context cues and provides a direct channel to express one's opinions.

The remainder of this document is structured as follows: section 2 describes some issues that are relevant to our work. Section 3 presents our tool for interaction analysis in collaborative learning environments, its agent-based architecture and the argumentation model proposed. Section 4 gives a brief overview of related works. Section 5 presents our conclusions and ideas for further work.

2. Relevant Issues

Computer Supported Collaborative Learning (CSCL) is a research area that investigates how the technology can support learning processes underlying the joint efforts of students working on specific tasks [27]. Collaborative learning encourages students who have a mutual aim of acquiring knowledge (and helping their peers to acquire) to interact with instructors and other students.

Computer Supported Collaborative Learning environments (CSCLEs) have the interaction as the key element to understand the process of knowledge building and the role of each student in that process. The analysis of the interaction can provide ways to support the individual and/or group needs, as well as improve the evaluation of different aspects (such as attitudes, weaknesses, knowledge level) of group/individuals behaviour. In order to analyse the interactions occurred into CSCL environments, we investigated argumentation models [11] as a way to structure these interactions and a data warehouse to store structured interactions, considering their multidimensional aspect. This section discusses these issues in detail.

2.1 Argumentation Models

Proper communication and orientation are necessary (but not sufficient) requirements for efficient collaborative learning,. Empirical studies [8] show that additional structured guidance (e.g. the use of an argumentation model can help students focus on the task) is often beneficial for learning.
Argumentation models have often been applied as a mean of systematising the communication patterns between members of a group [3]. The use of an argumentation model (for instance, IBIS [11]) allows the classification of all elements of discussion in pre-established abstractions of the model (e.g. Argument, Statement, etc) and their connection via a set of relations also pre-defined (e.g. provokes, generates, etc.). This is the case, for example, of Belvedere [10], Quorum [14], ARCoPAS [9] and SISCO [5].
In our work we use an argumentation model to categorise the message exchanging among participants and also to organise the information that composes the interactions in a collaborative environment, so that it can be used to:

- Assist students´ learning,
- Support instructors in: (a) evaluating students´ learning strategies; (b) assessing students during the whole learning process; (c) elaborating new courses or reformulating existing ones; and (d) analysing the roles students are playing (e.g., tutor, non-motivated student, shy student, etc.) so that effective help can be provided, taking into account the needs of the group but keeping in mind the problems of each of its members.
- Promote reflection in both students and instructors.
- Provide a well-organised group memory, similar to a smart FAQ. This feature allows participants of specific contexts to take advantage of the past-experiences of other group members.
- Store the identified information into a suitable structure, taking into account that the interaction within a collaborative environment is multidimensional. In other words, issues such as access time, access locals, user knowledge level, role that users are playing during the interaction, etc. are relevant to quantify (or qualify) the information which composes the LIM and will be used in the analysis process.

2.2 Multidimensional Modelling

Issues such as access time, access location, user's knowledge level and user roles are relevant to qualify the information in order to further analyse the interactions occurred in a collaborative environment. Thus, each interaction has a multidimensional facet that needs to be considered during its organisation.
According to several authors [15, 22, 17], multidimensional modelling is the most frequently used technique in data warehouse design. This has motivated us to consider this kind of data structure to store the Learning Interaction Memory (LIM). Other features that make the use of data warehouse suitable for our project are: subject-oriented approach (depending on the dimension considered at each moment), integrated, non-volatile and variable during the time [20]. The time variation needs to be considered because a student that presented a specific behaviour in situation X, at a time Y, can present a different behaviour in that same situation X at a time W.
Using operations like accessing, detailing and crossover, the information stored in the data warehouse can be used to support the instructor by evaluating and helping his students, working like a workgroup memory. Likewise, the system can use such information to support the learner reflection. Such operations will be implemented by OLAP (On-Line Analytical Processing) [22, 8], allowing the system to explore the interactions in different levels and dimensions (such as time, context and student level). Using OLAP operators we can do qualitative ("Which are the most frequent problems that have been found during the learning process?") and quantitative ("How many explanations have one question provoked?") analysis.

3. An Analytical Environment for Collaborative Learning

The socio-constructivist learning approach [25] suggests that the learner is part of a social group and s/he needs to be able to question, discover and understand the world around her/him. Current communication technology has made the implementation of computational environments that support and encourage group interactions possible at a reasonable cost.
In such situations, teachers can analyse the interactions, encouraging the participation of students and stimulating cooperative problem solving. The complexity of such a task is proportional to both the number of participants and the quality of their interaction. To provide information to instructors (so that they are able to follow the evolution of students in the short, medium and long terms), it is necessary to analyse users' actions in the learning environment,

as well as to evaluate which relevant pieces of knowledge have been shared and how they can help group members (in an individual or collective way) to perform better.
In next sections we present our agent-based system architecture that organises, stores and analyses information related to the interactions that occur in collaborative learning environments and the argumentation model proposed to structure the LIM.

3.1 System's Architecture

In order to be able to analyse group interactions, our tool will be connected to a CSCL environment. More specifically, our tool will communicate with the User Interface, Student Evaluation Modules and Student Model, all standard components (always present) of CSCLEs.
Figure 1 shows our tool's agent-based architecture [31]. It consists of an Agent Society composed by three agents: Perceptor, Modeller and Action Agents. Two models are also present: the Argumentation and the User Models. The Agent Society stores structured informations in a Learning Interaction Memory (LIM) implemented using a data warehouse to allow Analytical Queries and to keep historical informations about the discussions in the CSCL environment.

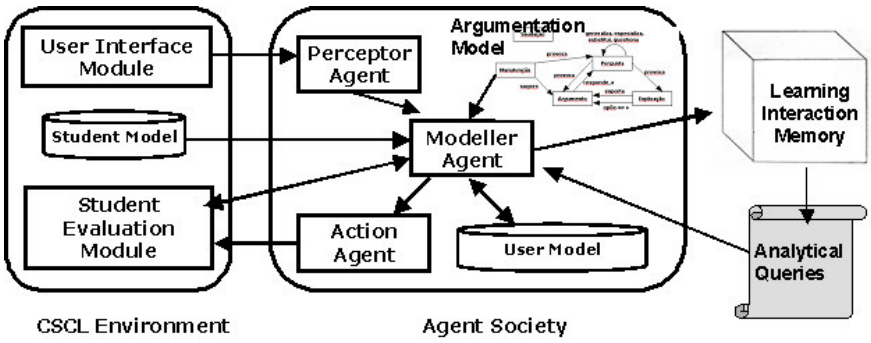

Fig. 1. Interactions Analysis System Architecture

The Perceptor Agent is responsible for monitoring all user interactions occurred in the learning environment and forwarding them to the Modeller Agent. The Modeller Agent is responsible for supporting students´ reflection as well as teachers´ decisions. It has three main functions: (1) uploading the data warehouse, based on the Argumentation Model adopted for the users' environment; (2) discovering the best strategy to adopt in order to promote reflection, based on the interactions analysis (through Analytical Queries to the LIM where user interactions are stored) and users´ models queries (to the CSCL environment's Student Model and Agent Society's User Model); (3) managing the Agent Society as a whole. Finally, the Action Agent is responsible for sending informations to the CSCL environment.
The Agent Society's User Model will be model through the following stereotypes: challenger, agreer, remiss, tutor, contributor, questioner, and unnatentive. Students will be classified into one of these categories according to their participation in the interactions environment.
The Modeller Agent needs to access structured interactions to execute its activities. In order to structure the interactions we could have used other dialog models, like dialogue games, as used in [30], or sentence openers, as used in [29]. However, as opposed to argumentation models, such models do not define dialogue episodes as precisely as we need in data warehouses. When a student use an abstraction to categorise her/his message, s/he needs to reflect about what s/he is going to write, and reflection is the most important skill in effective learning. Although sometimes choosing an abstraction to categorise one message can be tedious, this action helps to organise large volumes of messages and to lessens the participants' information overload [14]. Moreover, this process reduces the noise during communication, allows persistence of exchanged ideas for future reference (function of our LIM), helps to improve the resolution of conflicts and the comprehension of problems, and enhances traceability of the discussion.

3.1 A Model for the Learning Interaction Memory

In order to support interactions in learning environments, we have developed a model for the LIM. It is an extension of the IBIS argumentation model (Fig. 2) and have the following abstractions:

- Proposal - used when the participant (student or teacher) wants to introduce a theme for discussion. For example, "Let's talk about Argumentation Models".

- Argument - used to express a point of view or to explain contributions. In other words, an argument is used to express ideas, reasons for or against questions, examples and arguments. For example, "I agree with you because your explanation was clear" or "I think that using an argumentation model is interesting."
- Question - used to clarify doubts, ask someone to do something or challenge somebody to take part in a contest or to prove or justify something. For example, "Are you really sure about your answer?" or "What is an argumentation model?"
- Justification - used to clarify doubts and misunderstandings. For example, "an argumentation model provides a way to categorise the message exchanging among participants into a collaborative environment". This abstraction is used to answer a question.

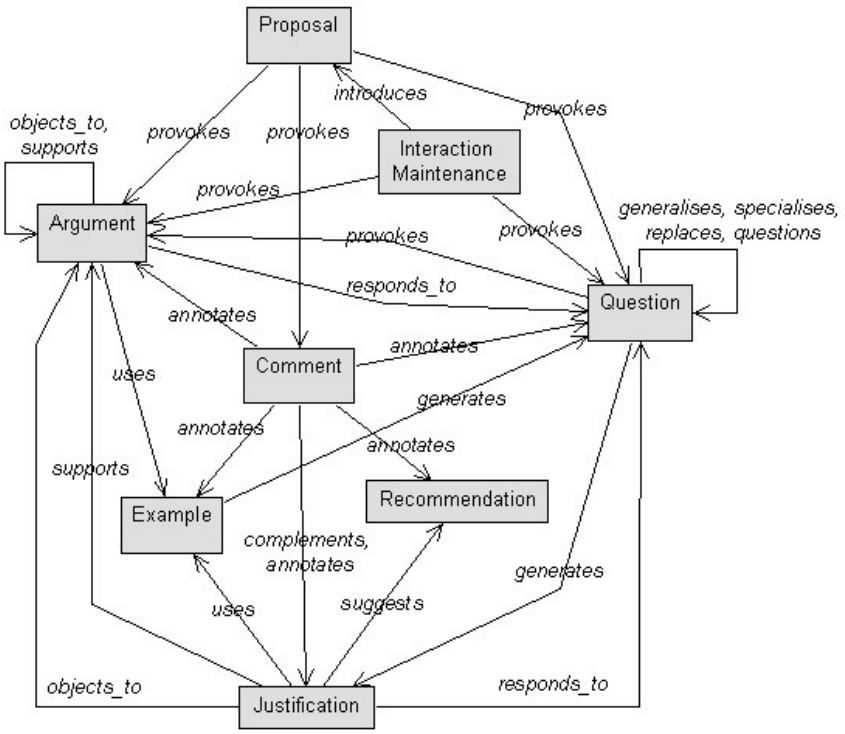

Fig. 2. A model for Learning Interaction Memory.

- Example – used to illustrate an explanation or an argument. For example, "IBIS is an example of argumentation model".
- Comment – used to complement an explanation, stimulate the student to summarize or add notes to an argument, explanation or question. In other words, comments can be used to give feedback for somebody. For example, "your explanation was very good".
- Recommendation - used to recommend references, a course of action or people to help in something. For example, "I think you should read so-and-so´s book".
- Interaction Maintenance – includes expressions used just to keep the communication channel open. For instance, "Hi, how are you?" or "Are you there?" are classified in this category.

A discussion using a learning environment is composed by all those categories. Upon sending a message, participants have to select the message category that best reflects their intention. In other words, users need to select one of a pre-defined set of appropriate utterance categories (e.g. argument, question, example, comment etc.), that provide explicit information about the content of their messages, for example:
User1 (tutor): PROPOSAL -> "Let's talk about the concept of context"
User2 (student) : COMMENT -> "It is a very interesting subject".
User3 (student): PROPOSAL -> "I propose that we talk about ontology before context"
User3 (student): ARGUMENT -> "If we talk about ontology before, it will be better to understand the idea of context first".

Consequently, the computational environment will be able to take advantage of the semantic knowledge of the categories and explicit relations among messages (e. g. if a QUESTION abstraction was used in a message, other message related to it, using our argumentation model, should use one either JUSTIFICATION, ARGUMENT or COMMENT) to organise and infer information, which will support the discussion processes. Additionally, the use of an argumentation model can help to improve conflict resolution and problem comprehension, making it easier for participants to clearly organise their ideas, better understand each other's points of view and arrive at a consensus more quickly. Once they have been categorised, messages can be stored, creating the LIM.

4. Related Works

Over the past decade, we have seen an explosion of network-based technologies that enable distant learners to work collaboratively. These CSCL environments enhance traditional distance learning curricula by giving students the opportunity to interact with other students and share ideas.

Several research projects have begun to explore the possibilities of enriching CSCL environments with tools to support collaborative interaction [21]. In many cases, interaction analysis has made use of Artificial Intelligence techniques to support their processes. However most systems have focused their analysis on quantitative and temporal elements, such as register and login of students to evidence the time of access and answer, number of students' interactions, number of correct answers and so on. More interesting approaches (e.g. [12, 24, 26, 28, 30]) have considered, in addition to these quantitative elements, qualitative factors such as the relation between a particular interaction and the past ones, as well as the analysis of the information composed by all interactions carried out during the whole learning process.

Even most modern collaborative learning systems still lack ways of supporting learner's reflection, although several works consider reflection as one of the most useful mechanisms during the learning process [19, 30, 18]. In this light, our work aims at filling in these gaps, providing ways of supporting reflection of both students and instructors, via analytical queries that can be performed on the structured interactions composing the LIM. Furthermore, using analytical queries, instructors will have access to information that supports a continuous evaluation of their students, their learning strategies and the lessons' content. Finally, the analytical queries will be a complementary tool to instructors that want more indicatives to the proper moment of interacting and motivating their students. All of these capabilities can significantly improve the potential of success of computer based learning processes.

5. Conclusions and Further Work

When an instructor decides to use Computer Supported Collaborative Learning Environments, the need for tools to evaluate and watch students taking into account interactions that occur among students and/or students and the teacher comes to light. This is due to the fact that during discussions students can think about what they did and learned, and share their knowledge with each other.

In computer-mediated education, an extremely important role of instructors is to mediate and encourage discussions. This task, however, can be troublesome when the number of participants and quantity of interactions tend to increase. So it is necessary to provide resources and information to instructors so that they can follow the evolution of students in short, medium and long terms.

In this paper, we propose a process to structure, store and query the information referring to the participants' interactions in a CSCLE. Indeed, in our analysis interactions tool, an agent society monitors the learning environment and all discussions are structured by the use of an argumentation model, which organises the types of contributions that participants make during discussion, and the way these relate to each other. A learning interaction memory is used to store the information (in a multidimensional structure). As the LIM is implemented using a data warehouse technology, analytical queries are useful to generate reports giving details of how the discussion is progressing.

Besides the analytical query mechanisms that provide several types of information to instructors, we consider that this proposal can help to evaluate the outcomes of using a tool like that in a learning environment. Teachers can also take advantage of such a tool, considering it as a support to decide on changes in their teaching strategy.

Our future research will concentrate on investigating how the concept of context [7] can be used in learning situations and formally modelling our argumentation model (using UML diagrams [6] and/or entity-relationship diagrams [15]).

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