Supporting Teachers Intervention in Collaborative Knowledge Building

Weiqin Chen

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Abstract. In the context of distributed collaborative learning, the teacher's role is different from traditional teacher-centered environments, they are coordinators/facilitators, guides, and co-learners. They monitor the collaboration activities within a group, detect problems and intervene in the collaboration to give advice and learn alongside students at the same time. We have designed an Assistant to support teachers intervention in collaborative knowledge building. The Assistant monitors the collaboration, visualizes it and provides advice to the teacher on the subject domain and the collaboration process.

1 INTRODUCTION

In collaborative learning, instruction is learner-centered rather than teacher-centered and knowledge is viewed as a social construct, facilitated by peer interaction, evaluation and cooperation. Therefore, the role of the teacher changes from transferring knowledge to students (the "sage on the stage") to being a facilitator in the students' construction of their own knowledge (the "guide on the side") [1].

According to Dillenbourg [2], the teacher retains an important role in the success of collaborative learning. As a facilitator, a teacher should not provide the right answer or say which group member is right, but perform a minimal pedagogical intervention (e. g. provide some hint) in order to redirect the group work in a productive direction or monitor which members are left out of the interaction.

The teacher's role in distributed collaborative learning depends heavily upon observation of the interaction. An intensive collaboration, however, which includes a relatively large number of messages or interactions, makes it difficult to follow. It is always time and effort consuming to analyze the collaboration, detect problems and give useful advice to regulate the collaboration. To support teachers facilitating role in collaborative knowledge building, we have designed an Assistant for FLE3-distributed collaborative learning environment developed by Media Lab, Univ. of Helsinki in Finland.

The rest of this paper is organized as follows. Section 2 gives a brief introduction of FLE3 in order for readers to understand the role and functions of the Assistant. Section 3 presents the design of the Assistant and its integration with FLE3. Related work is discussed in Section 4. Section 5 concludes the paper and presents some issues for further discussions.

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2 COLLABORATIVE KNOWLEDGE BUILDING

FLE3 [3] is a web-based groupware for computer supported collaborative learning (CSCL). It is designed to support collaborative process of progressive inquiry learning (Figure 1). The basic idea of progressive inquiry is that students gain deeper understanding by engaging in a research-like process where they generate their own problem, make hypotheses and search out explanatory scientific information collaboratively with other students.

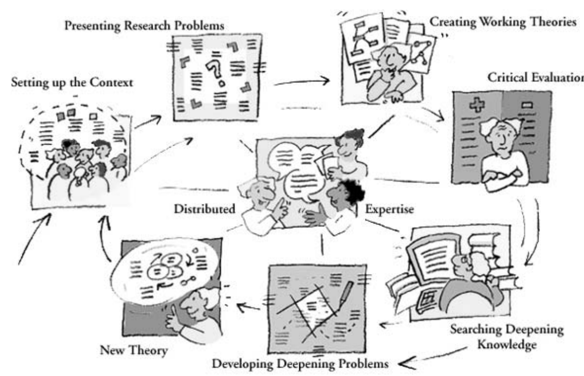

Figure 1. Progressive Inquiry Model

As a starting point, the teacher has to set up the context and the goal for a study project in order for the students to understand why the topic is worthwhile investigating. Then the teacher or the students present their research problems that define the directions where the inquiry goes. As the inquiry proceeds, more refined questions will be posted. Focusing on the research problems, the students construct their working theories, hypotheses, and interpretations based on their background knowledge and their research. Then the students assess strengths and weaknesses of different explanations and identify contradictions and gaps of knowledge. To refine the explanation, fill in the knowledge gaps and provide deeper explanation, the students have to do research and acquire new information on the related topics, which may result in new working theories. In so doing, the students move step by step toward answering the initial question.

To support collaborative progress inquiry process, FLE3 provides several modules, such as WebTop and Knowledge Building module. The WebTop module is a supporting module where teachers and students can store and share resources such as documents and links. The Knowledge Building module is considered to be the scaffolding module for progressive inquiry, where the students post their messages to the common workspace according to predefined categories. The categories they can use are Problem, My Explanation, Scientific Explanation, Evaluation of the Process, and Summary. These categories are defined to reflect the different phases in the progressive inquiry process.

3 ASSISTANT DESIGN AND IMPLEMENTATION

In the collaborative learning process in FLE3, teachers can contribute to the progressive inquiry process in the following aspects: to setup a context, to enhance the discussion by presenting problems or working theories, to encourage students to join the knowledge building session by sending student emails with links to relevant and interesting notes in the knowledge building, and to upload learning materials and inform students and let them visit the new material. To support the teachers role, the Assistant is designed to include both domain model and collaboration model. It helps the teacher to monitor the updates in WebTop and Knowledge Building module. If the teacher finds interesting material/notes in the updates, he/she can send emails to students with links to those material/notes. The Assistant also presents statistical information and gives advice to teachers based on the domain and collaboration models. It can also learn from the teachers feedback in order to improve its performance.

Figure 2 shows the integration of the Assistant with FLE3. The Assistant receives messages and activities of both students and the teacher through from FLE3 and stores them in a database. The activities are mainly logon/off, updates on the virtual WebTop module, updates in the Knowledge Building module and teacher's activities on the advice from the Assistant. Each of the activities has timestamp and other properties. For example, a message posted in the Knowledge Building module should also include message content, post person, category, and corresponding message. The Assistant can provide statistical information of the collaboration process, generate and present advice, and send emails on behalf of the teacher.

The Assistant has two interfaces in FLE3, one for the teacher and one for the students. The teacher interface has links to the following information:

- Who is online: By clicking on this link, the teacher can see all the students who are online.
- Update in WebTop: This links to the update in student's WebTop. The teacher can see all the new documents on the WebTop.
- Update in Knowledge Building: This links to the update in the Knowledge Building module. The teacher can check all the new messages posted since the last time he/she logged out. If he/she finds some notes are interesting, he/she can send emails to the students with links to those notes.
- Check statistics: Clicking on this link will trigger the statistic Computation module to go through the database, compute statistics on the collaboration process and present them in the form of tables or charts.
- Check advice: Clicking on this link will trigger the Advice Generation module to create advice by reasoning on the domain model and the information from the database using the rules in the knowledge base. The teacher can accept/reject or tailor the advice generated by the Assistant. He/she can also ask the Assistant to explain the advice or delegate the Assistant to send emails or present the advice to students.
- Topic management: This link allows the teacher to create and edit the domain model represented by a Topic map.

Except for the "Check advice" and "Topic management" links, the student interface has links to all the other information.

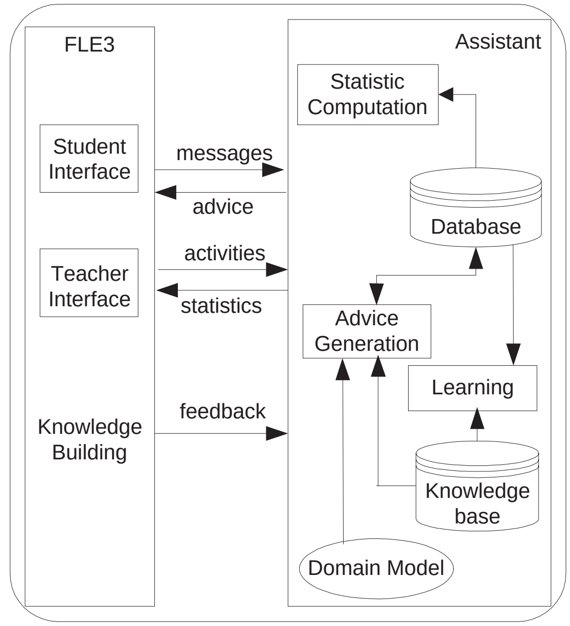

Figure 2. Integration with FLE3

3.1 Domain Model

A conceptual domain model is used to describe the domain concepts and the relationships among them, which collectively describe the domain space. A simple conceptual domain model can also be represented by a topic map. Topic maps [4] are a new ISO standard for describing knowledge structures and associating them with information resources. It is used to model topics and their relations in different levels. The main components in Topic maps are topics, associations, and occurrences. The topics represent the subjects, i.e. the things, which are in the application domain, and make them machine understandable. A topic association represents a relationship between topics. Occurrences link topics to one or more relevant information resources. Topic maps provide a way to represent semantically the conceptual knowledge in a certain domain.

In our prototype, we need to represent the topics and their relations and link them to the related notes accordingly. Topic maps can fulfill this requirement in a simple and friendly way. Furthermore, it is easier for teachers to understand and manage the Topic maps. This domain model includes topics in Artificial Intelligence (course domain) and their relations such as machine learning, agents, knowledge representation, searching algorithm, etc. These topics are described as topics in the topic map. Relations between the topics are represented as associations. The occurrence describes the links to the messages where the topic was discussed in the knowledge building process.

When a message is posted, associated topics to this message are selected. In the current version, we ask the contributors (students/teachers) to choose topics that their messages are related to. In next version, we plan to incorporate automatic classification techniques in information retrieval to link messages to the related topics.

Teachers can create Topic maps for their course domain and load /reload them into FLE3. Because Topic map are written in XML format, it is easy for teachers to understand and maintain the topics, and the domain model can also be easily reused in other contexts. Furthermore, The evaluation in a University course in fall 2003 shows that topic maps provide students with domain visualization and topic navigation which help them to get oriented within the course domain and deepen their understanding of the topics and their conceptual associations.

To analyze the interaction in the collaborative knowledge building process, the agent combines the structure (progressive inquiry model) and domain (conceptual domain model). The interaction is mapped to the progressive inquiry model and the course domain model. The progressive inquiry model is used to check if the discussion has followed the sequence of the knowledge building process. The conceptual domain model is used to check how the discussion covers the topics in the course domain.

3.2 Collaboration Model

In the knowledge building process of FLE3, the main activity of the students is to post messages according to categories. Therefore, the information collected and stored by the Assistant includes the properties of the messages posted by the students. It includes:

- Category: to which category a message is posted?
- Student-Post: who posts the message?
- Time-Stamp: when is the message posted?
- Msg-Correspond: to which message does the message correspond?
- Depth: at which depth of the thread is the message?
- Topics: What are the topics (in the domain model) that the message is related to?

By querying the database, the Assistant is able to provide statistical information on the collaboration process. For example, how many notes have been posted in each category? How many notes has a certain student posted? How often does a certain student post messages? How many notes has each student posted in a certain category? How many notes has a certain student posted corresponding to a certain message? How many notes are related to a certain topic in the domain model?

The Assistant presents the statistical information in tables or charts to teachers. Although this information is rather simple, it can provide valuable overview of the collaboration so that the teacher can follow the collaboration easily and detect problems quickly.

No. of Messages of Each User

User	Number of Msg
hegullak	0
Otto	9
men080	5
Paul	13
marius	7
tonydelabone	7
i3163	5

Figure 3. Number of messages by each user

For example, Figure 3 shows the number of messages posted by each student. The teacher would notice that student ”hegullak” has not made any contribution to the knowledge building. He/she can send ”hegullak” an email to encourage this student to join the knowledge building.

Number of msgs in each category

Thinking Type	Number of Msg
Problem	9
My Explanation	196
Scientific Explanation	31
Evaluation of the Process	1
Summary	0

Figure 4. Number of messages in each category

From Figure 4, the teacher can easily see that there are not enough messages in the category of ”Scientific Explanation”. It means that the research step in the inquiry progress model is not done properly by the students. This could be caused by either the students do not understand the scientific explanation category in progressive inquiry model well enough or they did not spend time working on scientific material. The teacher can further look into these possible problems and intervene when necessary.

The statistical information is also available to the students so that they can be aware of the collaboration process and their performance with respect to the group. The evaluation in a University course in fall 2003 shows that this could also help with the student's self-regulation.

3.3 Advice Generation

Although the statistical information can provide the teacher with an overview of the collaboration and the teacher can find some possible problems from checking this information, the problems that could be found based on this information is rather limited. To find other problems, the teacher need to look at the collaboration at a deeper level.

For example, according to the progressive inquiry model, the sequence of posting messages should be ”Problem”, ”My explanation” and ”Scientific explanation”. It means that the student should first post a message in a ”Problem” category, which should be followed by a message in a ”My explanation” category. Then he/she should post a message in a ”Scientific explanation” category. However, some students do not follow this sequence. Although this problem can be found by looking at ”category-number of message” table in the statistical information, it is not so straightforward. In addition, to find which student has this problem is even more complicated if the teacher only looks at the statistical information. To help the teacher find this problem, we create rules in the knowledge base to represent the ”perfect” sequence of the messages. The Assistant check each student's sequences of messages against these rules. If discrepancies are found, an advice will be generated to the teacher.

Figure 5 shows a short list of advice generated by the Assistant. The ”to” column shows the student's name to whom the email or

Figure 5. Assistant presents advice to the teacher

advice should be sent and "all" means to all students. The title column shows the title of the advice, and it is also the title of the email if the advice is decided to be sent to the student. In Figure 5, if the teacher clicks on the link title "knowledge building process" to student "tove", he/she will see a window pop up and it contains that content of the advice:

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From: weiqin.chen@infomedia.uib.no
To: tovesemailaddress@uib.no
Subject: knowledge building process

Hi tove,

I have noticed that you posted problems right
after problems. Are you aware of the
sequence in the progressive inquiry model?

Weiqin.
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The advice is given to the teacher and the teacher can view the advice and ask the agent to explain it. It is up to the teacher to make a decision on whether he/she should intervene, delegate the agent to present advice to the student or send emails to the student. The teacher can also save the advice to a file and review it later.

3.4 Learning

So far the Assistant has been using a fixed rule set to generate the advice. The lack of adaptivity affected the performance of the Assistant. In order for the Assistant to adapt the advice it generates and improve its performance, we tried two methods. One is to design a rule editor for the teacher to create and manage the rules in the knowledge base. The adaptivity is improved manually by allowing the teacher to create different rules for different situations. However, we find this method adding extra workload to the teacher. Another method we tried is machine learning. By learning from the teacher's feedback, the Assistant can automatically improve its adaptivity.

Among the existing learning algorithms, we picked up those that can learn rules. So far the learning algorithm we have experimented is CN2 [5]. It can induce new production rules periodically instead of doing it each time new feedback is provided. We believe that this feature fits asynchronous environments where real time update is not so crucial as compared to synchronous environments.

The input of the CN2 algorithm is the features of advice and the teachers activities to the advice. The features of advice include:

- Message feature: category, student-post, timestamp, and topics,
- Student feature: last-logout and last-message-post,
- Confidence factor: how confident the Assistant is on the advice.

The teachers activities include:

- present (delegate the Assistant to send/show the advice to students),
- explain (ask the Assistant to explain how it generates the advice),
- view the content of the message to be sent to students.

Each advice presented to the teacher becomes one training example for the CN2 algorithm in the form of feature set: {msg_feature, student_feature, teacher_activity, confidence}. Going through the training examples, CN2 creates a new set of rules and saves them. Afterward these new rules can be used in generating advice.

4 RELATED WORK

Roehler and Cantlon[6] classified the teacher's role in distribute learning environments into five categories: offering explanations, inviting students' participation, verifying and clarifying student understandings, modeling of desired behaviors and inviting students to contribute clues. The Assistant presented in this paper can help the teacher with inviting students participation, modeling of desired behaviors and inviting students to contribute clues. In addition, the Assistant can assist the teacher in finding problems in the coverage of the discussion topics and direct the discussion to other topics.

Jermann and his colleagues[7] provided a conceptual framework for collabration supporting tools and the capabilities they can offer based on the work by Barros and Verdejo[8] and reviewing of collaborative learning supporting systems. In Jermman and his colleagues' term, collaboration management can be described as a repetitive cycle containing four phases:

1. Data collection phase involves observing and recording the interaction.
2. Indicator selection involves selecting one or more high-level variables to represent the current state of the interaction.
3. Diagnosing interaction phase involves comparing the current state of the interaction to an ideal model of the interaction.
4. Remedial actions are proposed when discrepancies are found in Phase 3.

They further divided the collaborative learning supporting systems into three categories:

- systems that reflect actions (mirroring systems): collect raw data and display it to the collaborators,
- systems that monitor the interaction (metacognitive tools): model the state of the interaction and provide collaborators with visualizations that can be used to self-diagnose the collaboration;
- systems that offer advice: guide collaborators by recommending actions students might take to improve their interaction.

In their work, teachers are treated in the same way with students. There was no emphasis and support on the teacher's facilitator role.

To assist the teacher's facilitator role in the collaborative learning environment, the Assistant needs to have the ability to understand the collaboration to a certain degree. Several research works has been published in analyzing the interaction in collaboration. Gaßner and her colleagues categorized the methods that have been used in analyzing interaction into two dimensions[9]. The first dimension is classified into two categories based on raw data which the analysis methods operate on: activity-based and state-based analysis. The second dimension is classified into two categories based on the viewpoints under which the interaction was analyzed: summary analysis and structural analysis. In the second dimension, they further divided it into domain-independent and domain-specific interpretation of the analyzed data. In our work, we use both of the two dimensions for analyzing the collaboration in a simpler manner. For example, we use structural analysis only in domain-independent situation and summary analysis in both domain-independent and domain-specific situation.

5 DISCUSSION AND FUTURE WORK

This paper presented our ongoing project—an Assistant to support teachers intervention in collaborative knowledge building environment. A prototype has been implemented and evaluated in a university course in fall 2003, and some findings have been mentioned in this paper.

The evaluation was divided into two phases. In the first half of the semester, the students used FLE3 without the Assistant. In the second half of the semester, the Assistant was integrated into FLE3. One of the interesting findings is that the students thought that all the emails and advice were from the teacher. According to the evaluation, the students changed their behaviors following the advice from the Assistant.

The Assistant is designed to support the teachers facilitating role in the distributed collaborative learning by providing overview and advice. It does not replace the teacher. Instead it is a complementary to the teacher's role. The Assistant has its limitations in truly understanding the collaboration. The teacher has difficulties in following the collaboration. Therefore, the intervention is done by a Teacher-Assistant team. The abilities of the Assistant to explain the advice and to learn and improve its performance help to build up a trust relationship between the Assistant and the teacher.

In the prototype, a student has to pick up the topics from the domain model that are related to his/her message. We are currently looking at Artificial Intelligent techniques to automatically assign the messages to the topics in the domain model and reuse these messages as new learning material. We will also continue to evaluate alternative learning algorithms that are suitable for the Assistant.

FLE3 with Assistant will be further studied in fall 2004 in a university course. In this study, we plan to look into the reactions of the students to the advice from the teacher and the Assistant. It is possible that they would react differently if they know who creates the advice. Another issue that we would investigate further is the balance between flexibility and structure. One goal of the Assistant within FLE3 is to regulate the collaboration. However, one can ask if it is good to have this regulation or is it better to give students more flexibility? We hope the further experiments will help us to answer these questions.

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