Design of an Expert System to Enhance Learners' Critical Thinking in a Task-based Online Discussion

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Abstract: *Teaching-Learning Process* and *Technology* components in the principles of effectiveness for serving adult learners are the most important elements in empowering learners to be the co-creators of knowledge. There are various ways to blend teaching-learning process and technology components to enrich educational experience for the adult learners such as multimedia learning systems and learning objects. In this paper, we will discuss of how we have integrated *collaborative learning pedagogy* and *asynchronous discussion board* (forum) in order to design an expert system with the objective of promoting critical thinking aspects in a small group learning.

Keywords: expert system, collaborative learning, critical thinking, asynchronous discussion board, adult learners

Introduction

Open & distance education (ODE) and e-learning are fast becoming the way of providing education to the masses. ODE and e-learning give opportunity for the working adults to enroll in programs that match their interest without leaving their job. Serving adult learners are more challenging than serving in-campus students. According to CAEL (Council for Adult and Experiential Learning, US), there are eight principles of effectiveness for serving adult learners, namely outreach, life and career planning, financing, assessment of learning outcome, teaching and learning process, student support systems, technology and strategic partnerships.

We consider the *Teaching-Learning Process* and *Technology* components in the principles of effectiveness for serving adult learners as the most important elements in empowering learners to be the co-creators of knowledge. There are various ways to blend teaching-learning process and technology components to enrich educational experience for the adult learners such as multimedia learning systems (Sabatini 2001) and learning objects embedded with instructional design concepts. In this paper, we will discuss how we have integrated *collaborative learning pedagogy* and *asynchronous discussion board* (forum) in order to design an expert system that would be able to support the adult learners' online collaborative learning via small groups with the emphasize to enhance the critical thinking aspects of the groups and its members. One main objective of asynchronous learning community is as place to create critical thinking that will lead to knowledge construction. Thus, critical thinking is an important component in the students' online discussion in small groups that have diversified learners. In proposing the design framework, the following theoretical frameworks were used:

1. Collaborative learning pedagogy
2. Garrison's "community of inquiry" and "practical inquiry" models for critical thinking (CT)

3. Newman’s content analysis model to calculate the CT ratio

Theoretical Framework

Collaborative Learning

Collaborative learning is an established technique for teaching and learning (Preston, 2005, Yerion danRinehart 1995; Williams and Kessler 2000; McKinney and Denton 2006) in which the students in a group have their own learning responsibilities for each other and for themselves (Gokhale 1995). According to Preston (2005), this is a social process (Bagley and Chou, 2007) in which the learners learnt from peers by participating interactively with learning material, observing the solution approach adopted by every peers, ensure each peer is focused towards the task and motivated in highlighting issues and decisions. The potential benefits that can be obtained by the learners learning through collaborative learning are (Wilson JD, Hoskin N dan Nosek JT 1993, Yerion KA dan Rinehart JA 1995, Williams L and Kessler RR 2000, McKinney D and Denton LF 2006) resource sharing and cohesive brainstorming, monitoring of the problem solution approach by the peers, interactive is conducive for the good performance, positive effects on the cognitive growth and transmission and acquisition of kills, development of interest and sense of belonging, help the learners in applying problem solving techniques which is more algorithmic, sustainable deep learning, good performance achievement, increase the confidence level in giving the solutions and satisfaction on the process that was experienced. Collaborative learning could also be supported using computer through the Computer Supported Collaborative Learning (CSCL). This can be done using online visualization tools, community tools, chat and discussion forums. Asynchronous-based discussion tools such as discussion board or threaded forums facilitate communication among the learners which can be archived for reference. It also gives space to the students to think what to be typed in the discussion board (i.e. enables reflections). Numerous researches have highlighted the effectiveness of asynchronous communication as a learning source. The prominent research in this field was conducted by (Harasim 1990). Harasim discovered asynchronous environment can be used to enhance the learning process. This can be achieved through the combination of active learning and knowledge construction. Environments that have the interactive and asynchronous aspects enable active learning. According to Harasim, knowledge is constructed through generation, linkage and structuring of idea through online mode of communication. (Hiltz and Wellman 1997) in their studies found that asynchronous discussion is sufficient to support the development of learning community in which the students establish the both elements of cognitive and emotions needed for effective learning.

Garrison’s Model of Critical Thinking

The importance of cognitive development in online learning has been supported by (Garrison, D. R., Anderson, T., & Archer, W. 2000) and (Garrison, D. R., Anderson, T., & Archer, W. 2001) who believe with the creation of “community of inquiry” as a base for the development of critical thinking skills in online discussion. “Community of Inquiry” is characterized by question driven, critical discourse and information gathering among the learners. This model assumes that learning occurs in a community through the interactions of three elements, namely cognitive presence, social presence and teaching presence. According to (Garrison, D. R., Anderson, T., & Archer, W. 2000), cognitive element is the most important element for the successful online learning. In order to better understand cognitive presence in “Community of Inquiry”, (Garrison, D. R., Anderson, T., & Archer, W. 2001) have developed another model known as “practical inquiry model”. In this “practical inquiry model”, cognitive presence is operationalized through four pre-defined phases in which the active construction of knowledge occurs through the sequence of this phase. The first phase of the model reflects the initiation phase of critical inquiry and is considered the triggering event. Here an issue, dilemma, or problem that emerges from experience is identified or recognized. The second phase of the process is exploration. In this phase, students are required to perceive or grasp the nature of the problem, and then move to a fuller exploration of relevant information. The third phase, integration, is characterized by constructing meaning from the ideas generated in the exploratory phase. During the transition from the exploratory phase, students will begin to assess the applicability of ideas in terms of how well they connect and describe the issue or event under consideration. The fourth phase is a resolution of the dilemma or problem by means of direct or vicarious action. In all these phases, participants shift between the private, reflective world of the individual and the social exploration of ideas. The “practical inquiry” model shows clearly all the critical thinking processes that need to be experienced by the students to achieve cognitive presence in “community of inquiry”.

Newman Model of Content Analysis

There are various protocols that have been developed to calculate critical thinking (CT) ratio in order to perform the content analysis (i.e. analyzing the learners' transcript). Each of these has different scopes and objectives. We have adopted Newman content analysis model (Newman, D. R., Webb, B., & Cochrane, C. 1995) as it is based on Garrison's "practical inquiry" model which is also a framework used in this study. Newman's content analysis model has instantiated indicators of critical thinking via approximately 40 codes in categories such as relevance, justification, novelty, and ambiguities, each with a plus or a minus appended to indicate whether the coded statement contributes to (+) or detracts from (–) critical thinking development. This model proposes several sets of paired indicators – twenty pairs, five independent positive indicators and one independent indicator. They indicate that raters are to mark and count only obvious statements, which can be phrases, sentences, paragraphs, or messages containing one unit of meaning illustrating one or more of the indicators. Once a passage is coded, one calculates a critical thinking ratio as: $CT = (x+ - x-) \div (x+ + x-)$ where $x+$ is the count of statements contributing to critical thinking for the coding category and $x-$ is the count of statements detracting from critical thinking for the category. Positive numbers approaching 1 indicate the highest levels of critical thinking. Overall critical thinking ratio can be calculated by counting all the positive and negative postings in the forum and then apply the above formula. (Newman, Webb and Cochrane 1995) also have mapped the relevant indicators of content analysis to each of the phases in the Garrison's "practical inquiry" model. This has made Newman's content analysis model and Garrison's "practical inquiry" model compatible to each other. The following figure summarizes of how each theoretical framework used in this study contribute to the development of the expert system.

The Proposed Architecture

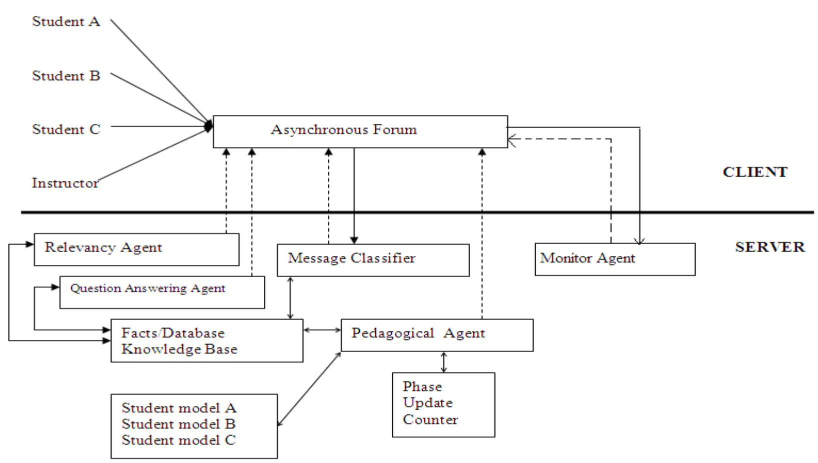

Figure 1: Main Components of the System

Figure 1 shows the components that make up the proposed system. The proposed system will use agent approach based on rule-based expert system in making the decisions. The rules will be built using Jess (Java Expert System Shell) inference engine that uses forward chaining algorithm. The facts and rules for the agents will be stored in Jess working memory and knowledge base respectively. The agent approach is adopted because it is goal oriented, take actions when necessary to achieve the goals, capable to complete the task given by the user, capable to monitor the environment and adjust the event without the intervention from the user. In discussions using forums, the task that can be done by the agents are sending messages to the students, classify the messages posted by the learners and models the conversation among the learners in the discussion group.

Students will be given a task or problem to be solved thorough collaborative discussion. They will be separated in groups which has two to three learners since effective collaboration learning only can be achieved if the number of the students in group is between two to six (Kovacs 1982). In order to do the discussion, the students will post their message in the asynchronous forum using sentence openers provided in the forum. Only one sentence opener can be used per posting to start the discourse. Subsequent sentences in the same posting should not use any sentence opener.

There is no restriction on the number of words per posting but each posting (which may consists more than one sentence) must highlight a *single issue*. This will enable the agents to do their tasks efficiently. Sentence openers are pre-defined approach to start a conversation using menu or buttons. We are motivated to use sentence openers based on the result obtained by Baker and Lund (1996). Baker and Lund (1996) compared the problem solving behavior of student pairs as they communicated through both a sentence opener interface and an unstructured chat interface. They found that the dialogue between students who used the sentence opener interface was more task focused.

In this study, the sentence opener that we have adopted is based on the Collaborative Learning Conversation Skill Taxonomy as suggested by (Soller et al. 1998) and (Soller 1996). This Collaborative Learning Conversation Skill Taxonomy illustrates the conversation skills most often exhibited during collaborative learning and problem solving. It breaks down each learning conversation skill type (Active Learning, Conversation, and Creative Conflict) into its corresponding subskills (e.g. Request, Inform, Acknowledge), and attributes (e.g. Suggest, Rephrase). Each attribute is assigned a short introductory phrase, or sentence opener, which conveys the appropriate dialogue intention (Soller et al. 1998) and (Soller 1996). There are 36 sentence openers in this taxonomy. The used of sentence opener in intelligent collaborative system is not something new. Sentence opener has been used in CSiLE (Bereiter and Scardamalia 1987) and in Group Leader (McManus and Aiken 1995). CSiLE is developed to increase the number of posting from the students. On the other hand, Group Leader compare sequences of students' conversation acts to those allowable in a four finite state machines developed specifically to monitor discussions about comments, requests, promises, and debates.

In our proposed expert system, each message typed by the students will first be parsed by the *Message Classifier* agent which will do the following tasks daily:

(i) Identify which sentence opener that has been used by the students
(ii) Identify the main keywords used by the students in completing the sentence (sentence closer) using the sentence opener
(iii) Based on the sentence opener and sentence closer used by the students, the agent will classify the message as either *discussion messages*, *not relevant message* (such as "how are you?") or *specific question* from the students on the domain or problem that need to be solved. The agent will ignore any other message that could not be classified.
(iv) If the message is classified as discussion message, the agent will assign appropriate indicator(s) available in Newman's content analysis model (Newman, D. R., Webb, B., & Cochrane, C. 1995). Here a message can have more than one indicator depends on the keyword used in the sentence closer.
(v) The agent will send reminder to the students if they do not use the sentence opener at all in drafting their message or inappropriate use of the sentence opener (such as "I agree not to agree")
(vi) If the message is classified as question asking on the domain or about the problem, the *Question Answering* agent will answer the question by giving few possible answers to the questions asked by the student earlier. If this agent could not answer the question, it will ask the instructor/tutor to answer it.

After the Message Classifier agent performed its tasks, the *Pedagogical Agent* will swing into action (2 times in a week) to do the following tasks using all the messages classified as *discussion messages* and has been assigned the content analysis indicators by the Message Classifier agent earlier:

(i) Calculate the critical thinking (CT) ratio of the individual learners and the groups for each of the category in the Newman's content analysis model (Newman, D. R., Webb, B., & Cochrane, C. 1995). In calculating the CT ratio, only the messages that relevant to the current Garrison stages will be taken into consideration. Other messages which are considered not relevant for current phase will be ignored. The *Phase Update Counter* keep track on the progress of the phases.
(ii) Identify the number of messages that are off topic
(iii) Monitor learners' and groups' CT ratio in moving from one phase to the another

(iii) Based on (i) and (ii) above, the Pedagogical agent will give its feedback, advice or consultation to the students or/and their group if:

-CT ratios of the student and/or the group is very far from 1

-There is a big difference between individual CT and his/her group's CT

-Too many off topic postings

- Lack of progress in terms of CT ratios of the individual learners and his/her group's in moving from one phase to the next phase

(iv) Finally, the student model will be updated accordingly by this agent

The *Monitor Agent* will monitor students' participation level in the discussion forum. This agent will send postings/message or reminders in the forum to the students who are not active by asking them to participate actively in the discussions. This is to ensure that there are plenty of postings so that other agents can perform their tasks. This agent will perform its task for every four days. This agent will also submit the participation report to the instructor as well for follow-up actions.

(Newman, Webb and Cochrane (1995 also have mapped the relevant indicators of content analysis to each of the phases in the Garrison's "practical inquiry" model. .The *Relevancy Agent* will use this mapping information to give reminders to the students if message posted by them is not appropriate for the current phase that they are currently in. This is to ensure that the students are in the same level of discussion and there are no students ahead or left out in the discussion. On the other hand, *Phase update counter* will keep track in the transition of the phases in the Garrison's "practical inquiry" model. Phase Update Counter has its own schedule in order to update the phase. Phase update counter has influence on the Pedagogical and Relevancy agents as information from Phase Update Counter is used by Relevancy and Pedagogical agents in executing their tasks.

Each individual *Student Model* and the *Group Model* will include all the relevant information that are needed by the agents in executing their task. The relevant agents will give more attention to the learners who have CGPA below 2.5. Information in students' and groups' model will be updated accordingly by the relevant agents as they perform their tasks.

Conclusion

This paper has proposes an architecture for an expert system to enhance learners critical thinking in solving a task/problem online collaboratively through asynchronous discussion board (forum). This study is conducted in premise of that the learners learning is not so much a matter of building up correct responses or eliminating incorrect responses. The most important thing is for students to have the opportunity in a group to test the adequacy of their ideas. It is how critical thinking skills are developed in the online group discussion. Currently we are in the process of developing the system. The testing of the system is scheduled in May 2010.

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