Enhancing learning through the discussion forum

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Abstract

Asynchronous online discussion forums play an important role in adult online courses, and have many possible functions. Our experience in using the discussion forums in online courses for task-based collaborative discussion has led us to many questions about the optimal ways of using online discussion to support collaborative learning, such as how should instructors structure online discussions in a way that it promotes collaborative learning? What should instructors do to enhance learners' reflective thinking, critical thinking, or problem solving in online collaborative discussions? The challenges of using forum in learning have also been highlighted by many researchers. In this paper, we present a so-called "smart" discussion forum to support, monitor and facilitate task-based collaboration for the learning process of adult learners to advance their development of critical thinking.

Introduction

Online learning in open and distance learning which caters to adult learners differs from traditional face-to-face learning in many ways. One obvious difference is lack of direct face-to-face interactions among students or between students and instructor (Gao, 2009). The quality and quantity of student-student interaction and student-instructor interaction influence the quality for any course, online or face-to-face. In this regard, one of the challenges to teach online is to cultivate meaningful online interactions among adult students who have diversified background (Gao, 2009). To achieve this goal, the asynchronous online discussion forum is one of the most effective tools as it promotes reflection, frees learners from time and space constraints (Anderson, 1996) and provides abundant possibilities for communication. In online courses for adult learners, discussion forums have been used for a variety of purposes such as to discuss general issues of the subject matter; share and obtain resources and information from each other and more importantly act as centres for groups of students who work collaboratively on task assigned to them (Gao, 2009).

Problem statement

Asynchronous online discussion forums play an important role in adult online courses, and have many possible functions (Dennen, 2008). At the same time, our experience in using discussion forums in online courses for task-based collaborative learning has led us to many questions about the best possible ways of using online discussion to support collaborative learning, such as how should instructors structure online discussions in a way to promote collaborative learning? What should instructors do to enhance reflective thinking, critical thinking, or problem solving in online collaborative discussions? In fact, online discussion forums do not always live up to these expectations (Gao, 2009). This is more so for online task-based collaborative learning implemented through discussion forum. When asynchronous discussion forum is used to support the understanding of the subject matter among learners, there have been both successful and unsuccessful situations (Gao, 2009). There are times when passionate discussions started with one student sharing a piece of reminiscent experience, when discussions came alive with a thought-provoking question, and when a group of students argued keenly about their ideas. There are also times, however, when discussions failed to achieve the preferred goal (Gao, 2009).

Objective

The objective of this paper is to discuss the design and implementation of a smart forum to support, monitor and facilitate task-based collaboration for the learning process of adult learners to advance their development of critical thinking (CT).

Literature review

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 that 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 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. According to Du et al. (2005), there are three types of discussions or questions that can be implemented in an online learning environment via discussion forums, namely flexible peer discussion, structured topic discussion and task-based collaborative discussion. In terms of flexible peer discussion, learners are given few questions in a week and they need to respond to these questions. In structured topic discussion, the instructor will develop questions that need to be analysed and explained in detail by the learners. On the other hand, in task-based collaborative discussion, the instructor will not assign any questions to the learners but the learners must take the initiative to forward their questions or opinions and this strategy is normally used when the learners are given

online projects or assignment. Task-based collaborative learning is more promising as it is an established pedagogy which promotes learners' active contribution. The current computer supported collaborative tools fail to capitalise on the key functions of a forum as shown in **Table 1**.

Tool	Platform	Task	Performance indicator	Roles
COLER (Constantino-Gonzales & Suthers, 2000)	Real time non-forum	Concept learning	Participation, agreement with group procedure	Coach
iDCLE (Inaba & Okamoto, 1996)	Real time non-forum	Concept learning	Advice	Coach
Gracile (Ayala & Yano, 1998)	Real time non-forum	Concept learning	Appropriate student helpers, learning tasks	Coach
HabiPro (Vizcaino et al., 2000)	Real time non-forum	Concept learning	Ideal participation, motivation	Coach
LeCS (Rosatelli et al., 2000)	Real time non-forum	Concept learning	Participation, group coordination	Coach
Group Leader (McManus & Aiken, 1995)	Real time non-forum	Concept learning	Trust, leadership, communication	Coach
Epsilon (Soller & Lesgold, 2000)	Real time non-forum	Concept learning and problem solving	Knowledge construction	Coach
Our proposed "smart forum"	Asynchronous — forum	Problem solving	Critical thinking	Coach

Table 1 Comparison of various CSCL tools widely cited in the literature
Source: Adapted from Soller et al., 2005

Besides the problems regarding the forum that has been highlighted earlier, not much attention has been given to the function of a forum as a collaborative learning platform. Most CSCLs focused on using chat as a learning platform. In addition, a forum embedded in a learning management system (LMS) is merely a dumb interface with no active functions. One other interesting aspect was the element of critical thinking has been overlooked in all the existing CSCL tools. Critical thinking is an important skill that learners should acquire. Thus, there is a need to develop forum-based tools to address these issues.

System design

In this section, the design framework of the proposed smart forum system is discussed. The general overview of the system is shown in **Figure 1**.
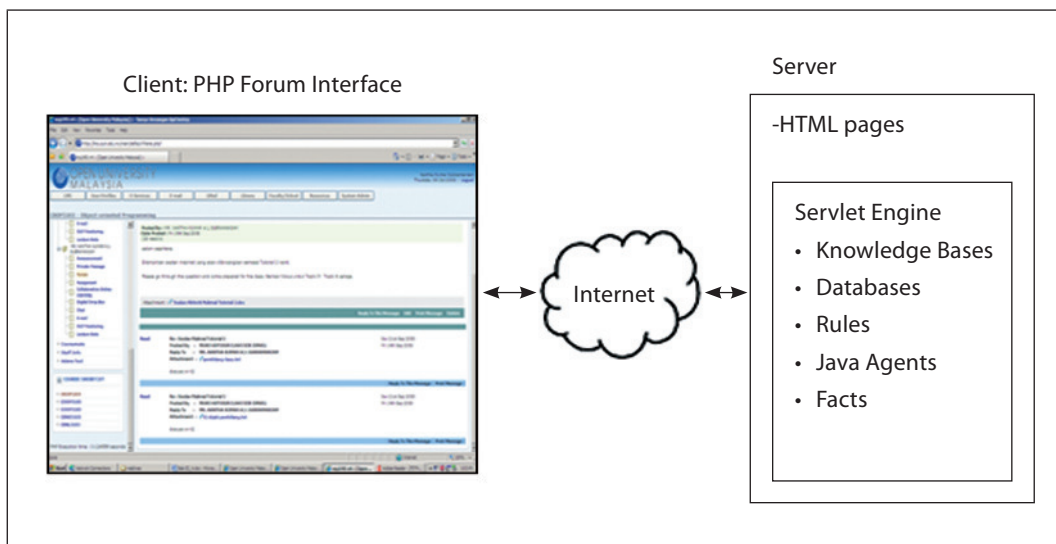

Figure 1 General overview of a smart forum

The proposed architecture of the system will use the agent approach which is based on the rule-based expert system framework. The agent approach is adopted due to its goal-oriented outcome in terms of the agent's ability to take action whenever necessary to fulfil the goal; capability to perform tasks given by the user autonomously; monitor the environment and adjust an event without direct intervention from the user. **Figure 2** shows the components that make up the proposed system. It has seven agents performing different tasks. The facts and rules for the agents will be stored in the knowledge bases. In a smart forum, students are given a task or problem to be solved through collaborative discussion in a small group. In order to engage in the discussion, students have to post their messages 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 sentence(s) 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 consist of 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.
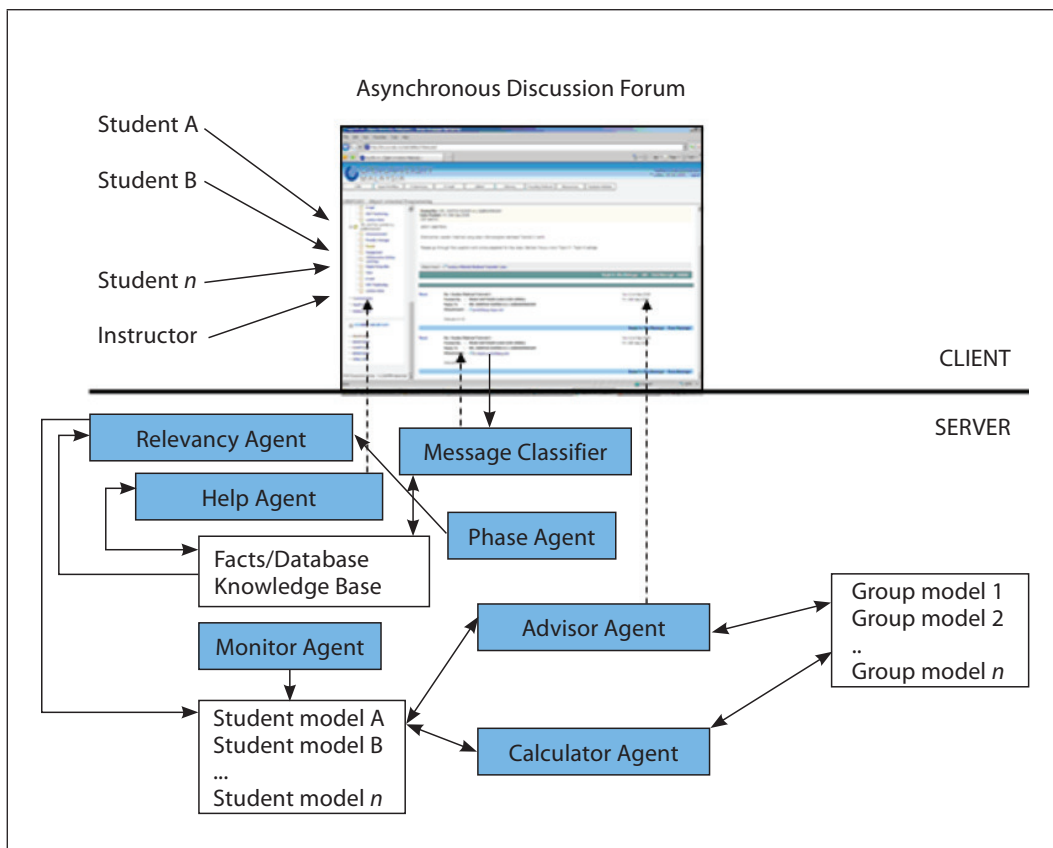

Figure 2 Architecture of the smart forum

We are motivated to use sentence openers based on the result obtained by Baker and Lund (1996). In this study, the sentence opener that has been adopted is based on the Collaborative Skills Network (CSN) proposed by Israel (2003). Israel's (2003) model is adopted as it has included more "working on task" sentence opener which are appropriate for task-based discussions. In our proposed expert system, each message typed by students using the sentence openers will first be parsed by the **Message Classifier** agent that will do the following tasks:

i.   Identify which sentence opener that has been used by students and tutors. Tutors and students are given separate set of sentence openers (**Figure 3**).

ii.   Identify the main keywords used by students in completing the sentence (sentence closer) using the sentence opener. The analysis is done using Knuth-Morris-Pratt string matching algorithm.

iii. Based on the sentence opener and sentence closer used by students, the agent will classify the message as either *discussion messages*, *not relevant message* (such as "how are you?") or *specific question* from students on the domain or problem that needs to be resolved. The agent will ignore any other messages that cannot be classified.

iv. If the message is classified as a discussion message, the agent will assign appropriate tag(s) available in Newman's content analysis model (Newman et al., 1995). Here, a message can have more than one indicator depending on the keyword used in the sentence closer.
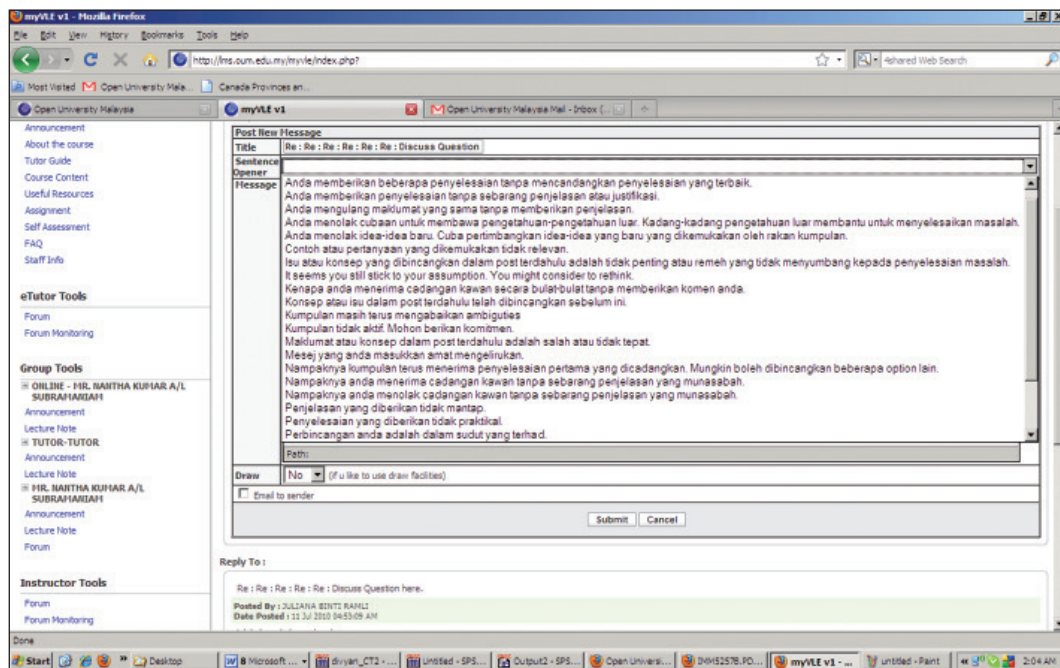

Figure 3 Sentence openers are provided as pull-down menu (student view)

The **Calculator Agent** will calculate the critical thinking (CT) ratio of the individual learner and the groups for each of the category in the Newman's content analysis model (Newman et al., 1995). 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 – 20 pairs, five independent positive indicators and one independent indicator. Rater only mark and count obvious statements, which can be phrases, sentences, paragraphs or messages containing one unit of meaning illustrating one or more of the indicators. In a smart forum, the calculator agent will automate all these processes. In calculating the CT ratio, messages that are relevant to the groups' current phase in Garrison's "practical inquiry model" (Garrison et al., 2001a; Garrison et al., 2001b) will be taken into consideration. It

will also calculate the cumulative CT ratio of learners and groups independent of the phases. The formula used by the calculator agent to calculate the CT ratio is given below:

$$CT = (x+ - x-) \div (x+ + x-)$$

$x+$: is the count of statements contributing to critical thinking for the coding category $x-$: 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.

The *Monitor Agent* will monitor students' participation level in the discussion forum. This agent will send postings/message or reminders in the forum to students who are not active by asking them to participate actively in the discussions in a week. This is to ensure that there are plenty of postings so that other agents can perform their tasks. The formula used to determine student activeness is based on the learners' out-degree centrality of their discussion (Suh & Lee, 2006):

$$d_o(M_o) = \frac{d_o}{(g - 1)}$$

$d_o(M_o)$: Out-degree centrality for student M_o
d_o: sum of messages that the participant sends toward others
g: number of participants in the group

Learners with high out-degree centrality are more active in providing information to others in a discussion or providing comments on the opinions of others. Newman et al. (1995) have also mapped the relevant indicators of content analysis to each of the phase in Garrison's "practical inquiry" model. If a message is tagged by the Classifier agent, the *Relevancy Agent* will use this mapping information to update the relevant parameters in the student model regarding the status of the current message posted by learners (i.e., whether the message is appropriate for the current phase or not). This is to ensure that students are in the same level of discussion and that there are no students ahead or left out in the discussion. The *Phase Agent* will keep track of the transition of the phases in the Garrison's "practical inquiry" model (i.e., initiation, exploration, integration and resolution). Only the tutor is allowed to change the phase of the group and the phase agent will notify the relevant agents if there is any change of phase for the groups. The phase agent will also identify in which phase a message has been posted by the student. This information is vital for the relevancy agent. The phase agent influences the calculator and relevancy agents i.e., information from phase agent is used by these two (calculator and relevancy) agents in executing their tasks. The *Help Agent* will provide possible answers for student's queries pertaining to the subject matter in the form of

FaQs in a new pop-up window. If the agent cannot give the possible answers or if the student is not satisfied with the answers given by the agent, the student has the option to alert the tutor by just clicking an alert button provided by the agent on the same screen. When this is done, the agent will send the user's searched keyword together with their email details to the tutor. The tutor can then reply to the student with the appropriate answer.

Information in students' and groups' model will be updated accordingly by the relevant agents as they perform their tasks. The student model for each of the student stored in the database table consists of the following information: CT ratio of the phase, overall CT ratio, magnitude of learners' activeness (out-degree centrality ratio), indicator of relevant message tags posted in a message for a phase, learners CT ratio of the prior phase and information on the relevant tags for the latest posting. The group model consists of the following information: overall CT ratio of the groups, CT ratio for each phase, CT ratio of the group's prior phase. Finally, the ***Advisor Agent*** will swing into action to complete the following tasks using all the messages classified as *discussion messages* and those that have been tagged by the Message Classifier agent earlier:

i. Monitor learners' and groups' CT ratio in moving from one phase to another.

ii. Based on (i) above and the status of the students' and groups' model (written in the form of rule), the advisor agent will give its feedback, advice or consultation to the students concerned and/or their group (**Figure 4**). The feedback/advice/message that satisfies the condition of a rule will be fired by the agent. The rule is written in the form of IF-THEN statement and stored in a knowledge base. An example of rule written for the learner is given below:

```
if ( (CT_phase_student[counterStudent] < 0.45) && (increaseBetwee
nPhases[counterStudent].equals("NO")) && (active[counterStudent].
equals("NO")) &&
 improveRelPhase[counterStudent].equals("NO")) && (improveRelCur
rent[counterStudent].equals("NO")) &&
 (CT_o[counterStudent] < 0.45) )
```

A total of 128 rules have been written for the learners. An example of rule written for the group is given below:

```
if ( (CT_O[counterGroup] < 0.45) && (CTPreStatus[counterGroup].
equals("BAD"))
```

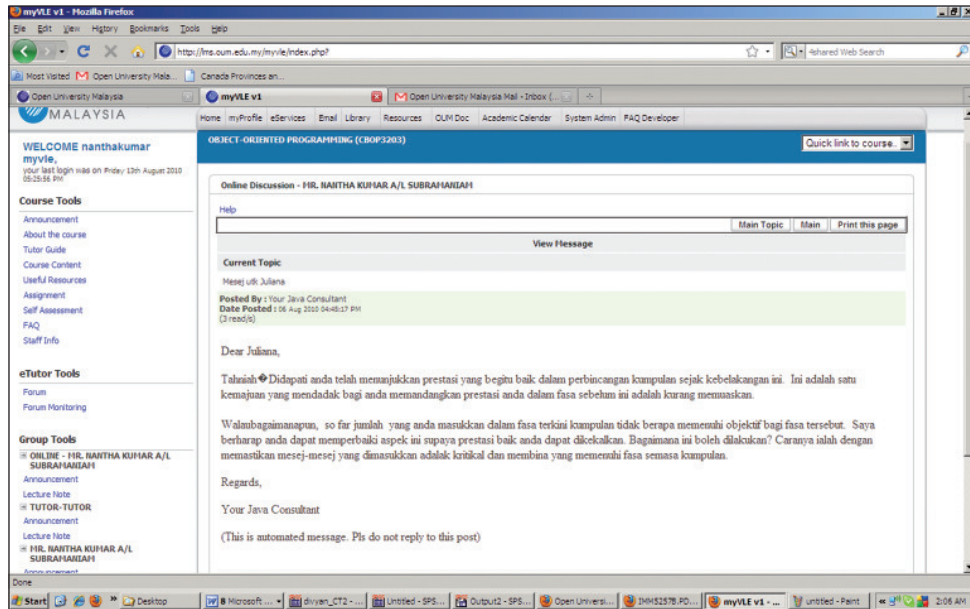A total of 64 rules have been written for the groups.

Figure 4 Example of message sent by the agent to a learner

Database and knowledge base

Databases used by the smart forum are elaborated in **Table 2** below.

Database	Description	Referred by agent
Pattern	This database has all the tags/indicators proposed in Newman content analysis model and the possible keywords (that matched these tags) that can be used by the learners in completing their message in a posting.	Classifier
AdviceLearner	This database contains all the messages that can be chosen by the agent when giving the feedback to the individual student.	Advisor
AdviceGroup	This database contains all the messages that can be chosen by the agent when giving the feedback to the group.	Advisor

Table 2 Databases in the smart forum

A Knowledge Base (KB) is a special kind of database for knowledge management, providing the means for the computerised collection, organisation and retrieval of knowledge. It stores all the information required by the agent. The smart forum has two knowledge bases to store the rules needed by the advisor agent as depicted in **Table 3**.

Knowledge base	Description	Referred by agent
RuleLearner	It has 128 rules required by the advisor agent to determine the type of message/advice that need to send to an individual learner.	Advisor
RuleGroup	It has 64 rules required by the advisor agent to determine the type of message/advice that need to send to the group as a whole.	Advisor

Table 3 Knowledge bases in the smart forum

Learner and group models

Learner and group models have all the information about student's and group's status that are needed by the agent in making decisions. The relevant tables that represent student's model are given in **Table 4** below:

Table	Description	Referred by agent
StudentModel1	Stores information regarding a student's critical thinking ratio according to the discussion phases and the cumulative CT irrespective of the phases.	Calculator, Advisor
StudentModel2	Stores information regarding number of messages that are relevant and irrelevant for the current phase of the discussion and for the past phases respectively.	Relevancy, Advisor
Monitor	Stores information regarding a student's participation level in the forum.	Monitor, Advisor
StudentProgress	Stores information regarding a student's past performance and current performance in the form of percentage.	Advisor

Table 4 Student model

The group model is represented by one table as shown in **Table 5** below:

Table	Description	Referred by agent
GroupModel	Stores information regarding group's critical thinking ratio according to the discussion phases and the cumulative CT irrespective of the phases. It also contains the following information: • Status of the group's phase transition • Group's current and past performances in the form of percentage	Calculator, Advisor

Table 5 Group model

Implementation

The agents in the smart forum were built by integrating the JACK agent environment using Java programming. These agents were involved in back-end processing of a LINUX server. The forum platform from Open University Malaysia's learning management system known as myVLE has been used as the forum front-end interface. mySQL has been used as the database to store all the information processed by the agent. **Figure 5** shows the some of the main interfaces of the system.
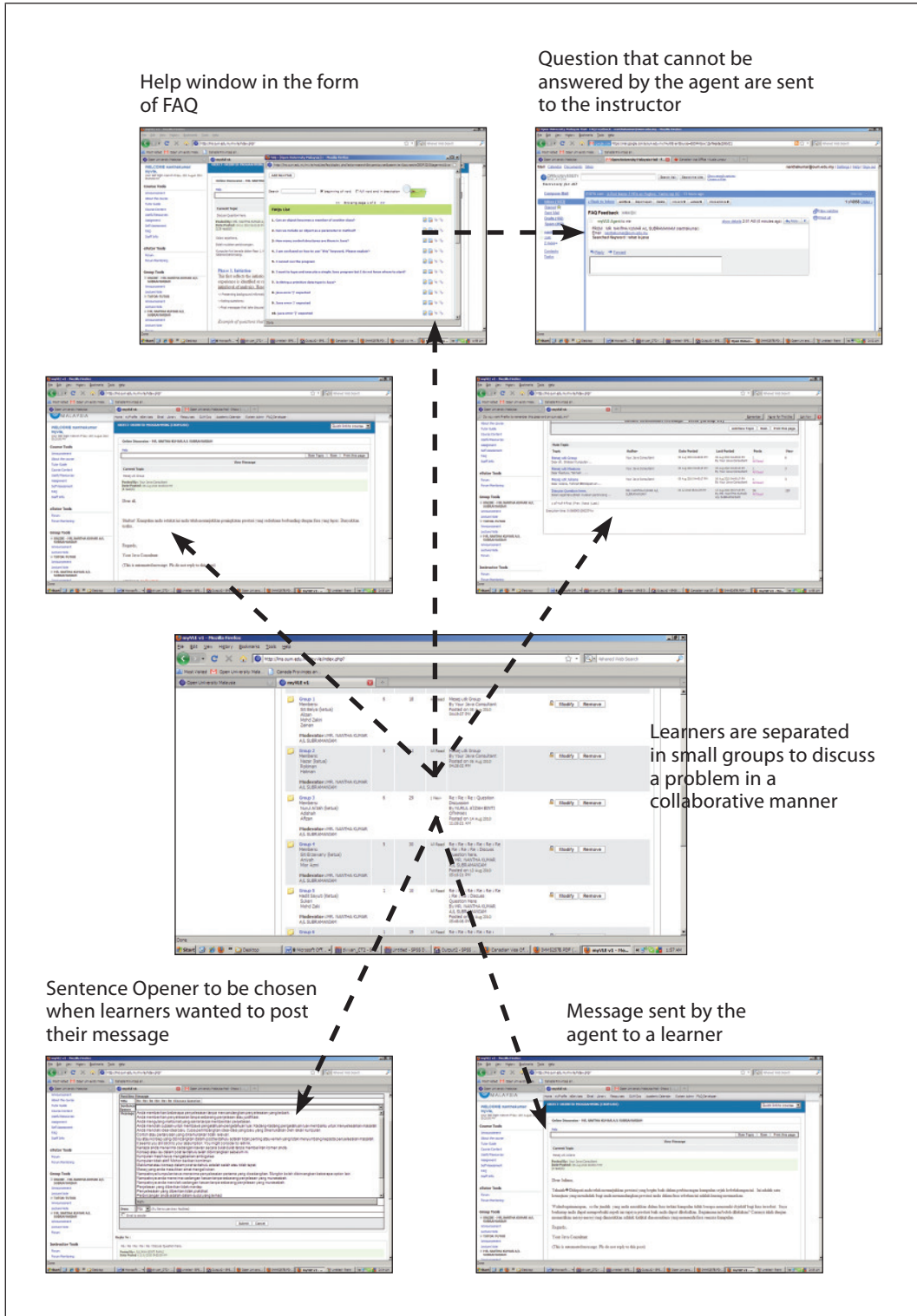
Help window in the form
of FAQ

Question that cannot be
answered by the agent are sent
to the instructor

Learners are separated
in small groups to discuss
a problem in a
collaborative manner

Sentence Opener to be chosen
when learners wanted to post
their message

Message sent by the
agent to a learner

Figure 5 The implementation of the smart forum

Learners' evaluation

The prototype of a smart forum has been evaluated by 20 learners who took a second year IT subject. They have been divided into six groups. Each group has 2–4 learners. They have used the system for one semester. At the end of the semester, a questionnaire was distributed to them. The questionnaire has 11 items and is measured using the Lickert scale of 1 (very weak) to 5 (very good). The mean score for all the items are shown in **Table 6** below.

	Item	Mean Square
1	How would you rate the user-friendliness of the forum?	3.75
2	How would you rate the ease of learning to use the forum?	3.75
3	How would you rate the accuracy of the forum? (accuracy refers to the correctness of the responses displayed by the forum)	3.5
4	How would you rate the usefulness of the "sentence openers"?	3.75
5	How would you rate the quality of the responses made by the forum? Quality refers to clarity and appropriates of messages responded by the forum.	3.75
6	How would you rate the usefulness of the forum for accomplishing your individual work?	3.5
7	How would you rate the usefulness of the forum for accomplishing your group work?	3.75
8	How would you rate the usefulness of the forum for collaborative discussions with your group members?	3.33
9	How would you rate the ease of using the forum interface for discussions with your group members?	4.0
10	How would you rate your overall satisfaction with the forum?	3.75
11	How would you rate the success of the forum? Success refers to whether you feel you learned more by using this forum than you would do without it.	4.0

Table 6 Mean score of the items

The result shows that learners gave favourable responses for the smart forum. The smart forum managed to provide an opportunity for learners to increase their discussion capability in the context of CT development.

Conclusion and future work

This paper has presented an architecture for a smart forum prototype which supports, monitors and facilitates adult learners' task-based collaborative discussion. The system was built using an agent approach utilising the conventional set-up of forums to enhance adult learners' critical thinking in solving a task/problem online collaboratively. The feedbacks from students show that the system has contributed to the enhancement of their capability and critical thinking skills on the subject matter. We are currently in the process of writing more rules for the system so that it can handle more problematic situations. We are also investigating ways to incorporate fuzzy logic and neural network in the system in order to increase the processing power of the agents.

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