Student-led inquiry-based learning

Thushani A. Weerasinghe, Robert Ramberg, and Kamalanath P. Hewagamage

Abstract— Inquiry-based learning and peer-teaching are two teaching and learning approaches best applicable in higher educational contexts. Considering benefits of each approach in learning, a study was conducted to determine how to design peer-teaching activities to promote inquiry-based learning. Data were collected from a group of instructional designers, a sample group of students in an online learning environment prepared for a distance learning programme and from the learning management system of the online learning environment. The findings of the study were used to improve sets of design principles that were followed to design the peer-teaching activity. In addition, sets of design guidelines were also prepared for easy application of the design principles.

Keywords—inquiry-based learning, peer-teaching, community of inquiry, online learning.

I. INTRODUCTION

PEER-TEACHING and inquiry-based learning are two learning approaches practised often in higher educational contexts. Peer-teaching has long been well accepted as it provides an opportunity for learners to learn twice by teaching others (e.g. [1], [2] and [3]). Peer-teaching enables learners to support each other by teaching what they know and learning from others what they do not know. Inquiry-based learning (IBL) on the other hand is a question driven approach for learning [4]. It enables students to learn by asking questions and finding answers.

Often problems raised by students at discussions are authentic in the sense that they are not only relevant to the course content and the subject under discussion but also are aimed at solving issues they come across while studying the subject content. Students can answer questions further by teaching and providing information required to envisage peers' understanding of the relevant subject matter. This implies that inquiry-based learning environments practising peer-teaching activities can provide a greater opportunity for students to

T. A. Weerasinghe was with the Department of Computer and System Sciences at the Stockholm University, 164 40 Kista, Sweden. She is now with the University of Colombo School of computing, 35, Reid Avenue, Colombo 7, Sri Lanka (corresponding author to provide phone: +94-11-2837495; fax: +94-11-2587239; e-mail: taw@ucsc.cmb.ac.lk).

R. Ramberg, is with the Department of Computer and System Sciences at the Stockholm University, 164 40 Kista, Sweden. (e-mail: robban@dsv.su.se).

K. P. Hewagamage is with the University of Colombo School of computing, 35, Reid Avenue, Colombo 7, Sri Lanka. (e-mail: kph@ucsc.cmb.ac.lk).

learn from each other and enhance their learning. This kind of learning encourages critical thinking and reflection and it can bring about deep and meaningful learning [5], [6].

However, in order to make inquiry process progress smoothly and support deep and meaningful learning, the online course components in particular discussion environments must be designed in such a way that tasks are engaging and cognitively demanding [7] and enable students to play active roles of both facilitator and learner. This requirement necessitates the study of how to design online courses for encouraging peer-teaching and inquiry-based learning specifically focusing on learner interactions because interactions can enable learners to develop their problem solving skills [8].

Researchers who investigated how to design inquiry-based learning activities have emphasized the importance of the role of online teachers or automated system functionalities for directing and leading discussions (e.g. [9] and [10]). Notwithstanding, Anderson in his theory of online learning reports that deep and meaningful learning can take place even if teacher interactions are not available in online course environments, but when student-student and student-content interactions are kept at very high levels [11]. In order to encourage more student-student and student-content interactions, online courses should be designed with appropriate instructional design methodology. According to Garrison and Cleveland-Innes [5], course design is a factor that can significantly impact on students' interactions and determine whether students can approach learning in a deep and meaningful way.

A previous study in a virtual learning environment revealed that its students could support each other in solving their problems and even teach small sections of lessons that seemed difficult to their peers [12]. The students could engage in deep and meaningful learning even though teachers were not present in the discussions. Based on the findings of the study, the authors supposed that the course design might be a factor leading the students to actively participate in the inquiry-based discussions. Considering this supposition and the students' tendency to participate in peer-teaching activities, we were motivated to further investigate what course components and their design features can stimulate inquiry-based learning and what instructions can support students to engage in a peer-teaching activity in order to promote inquiry-based learning in the same virtual learning environment (BIT VLE).

The BIT VLE was a customised version of Moodle learning management system. It was prepared by the University of

Colombo School of Computing (UCSC), Sri Lanka to deliver its online courses of the Bachelor of Information Technology (BIT) degree programme. The study was conducted using the 1st semester courses of the BIT programme. There were four courses: Information Systems and Technology (C1), Computer Systems (C2), Personal Computer Applications (C3), and Internet and World Wide Web (C4). The online courses were designed by a team of instructional designers at the e-Learning Centre of the UCSC.

The course consisted of interactive learning content, student manuals in PDF format, discussion forums, activities, quizzes and assignments with automatic feedback. The discussion forums provided an opportunity for the students to discuss their concerns in particular to get their problems solved out by discussing with peers. A facilitator was there to assist students in the forums.

However, the UCSC found it difficult to support their students efficiently and cope with their increasing online student numbers. In order to mitigate the issue, in the following year, the UCSC assigned one facilitator for each course. However, as in other online courses with large number of students (e.g. [12]) the facilitators endured deficiency of time to provide responses to each student in their courses. As a solution, the UCSC and the others who encountered the similar issues were interested in introducing more and more student directed discussions providing students more opportunities to interact with each other and find solutions to course related problems by themselves [14], [15].

A. Research Questions

In order to encourage students to find solutions to their problems by themselves and engage in inquiry-based learning in an online course environment, its components and instructions should be designed with appropriate instructional design methodology. For this purpose instructional designers should know

1) What course components and their design features can stimulate inquiry learning?

Simply designing the course components may not be enough for active participation to take place in the inquiry process. Students should be provided with appropriate instructions to engage in peer teaching and inquiry learning. This consideration raises one more question;

2) What kind of instructions should be given to the students to engage in peer-teaching?

The paper attempts to answer the above questions by analysing a set of online discussions and content access records of the four online courses in the BIT VLE. In addition, since online learner behaviours can be influenced by individual students' learning characteristics and attitudes [16], a sample group of students' learning characteristics, experience, and attitudes towards peer teaching and inquiry learning were gathered and analysed. The students' learning characteristics, experience and attitudes were gathered at an online workshop where students participated in designing a peer teaching and inquiry-learning activity. The peer teaching

and inquiry learning activity was designed based on the theoretical perspectives of socio-constructivism [17] and student-centred learning [18].

B. Design Principles

The design of the activity was basically inspired by two design principles that Kali, Levin-Peled, and Dori [19] used in a study of promoting collaborative learning in a higher-educational context. The principles were as follows: (a) engage learners in instruction of their peers and (b) reuse student artefacts as resources for further learning. The principles were inspired by the theoretical perspectives of socio-constructivist learning. Even though the two principles can lead to design a peer-teaching activity, they do not specifically aim at guiding the design of inquiry-based learning (IBL). Therefore, we reformulated another set of design principles which was originally listed as a set of issues that instructional designers had to handle when practicing IBL and designing for self-regulated and learner-centred learning (see [9]). The list contained five issues which could be tackled by tools or students engaging in IBL and peer-teaching as follows.

1) Visual representation of the inquiry process: The inquiry process can be presented in a diagram and explained to the students how they should engage in the inquiry process.

2) Motivating learners with the right question: We can provide instructions to encourage brainstorming and start with a familiar topic and move into an ill-structured question which often can have multiple solutions and can be solved in different ways.

3) Engaging learners in various learning activities: If we can identify the activities students usually accomplish while engaging in the inquiry process, then we can support them to get their activities done efficiently and to enjoy inquiry-based learning.

4) Guiding the inquiry process with various scaffolds that students can use in different phases of the inquiry process, and

5) Maximising learning by coordinating resources, tools, and community of inquiry: We have to identify and make available the requirements to engage in inquiry-based learning. The students may tend to use the easy accessible resources and technology to interact with peers and develop a community of inquiry.

C. Community of Inquiry

A community of learners engaging in inquiry-based learning is referred to as a "community of inquiry". Understanding of learning processes in a learning environment can help to improve the teaching and learning processes in that environment [20]. In order to determine learning processes in an online community of inquiry we can analyse the discussion content using the Community of Inquiry (CoI) model which is widely used and continuously improved [21]. The model supports to identify social, cognitive, teaching, and metacognitive presences in online discussions. Social presence

represents learners' ability of projecting their personal characteristics in online discussion environment and presenting themselves to peers as "real people" [22]. Cognitive presence describes "the extent to which learners are able to construct and confirm meaning through sustained discourse" [23, p.1]. In a CoI, the teacher's role can be played even by students and their teaching activities are identified as teaching presence. Metacognition in a CoI is defined as the motivation for learning and the knowledge and skills required for monitoring and regulating cognitive processes of self and others [24].

Cognitive component is the key construct of the CoI model and it is based on the practical inquiry process (Fig. 1) of John Dewey [25], [22]. In accordance with the four phases of the practical inquiry process, the cognitive presence construct of the CoI model consists of four categories: triggering event, exploration, integration and resolution (see Appendix).
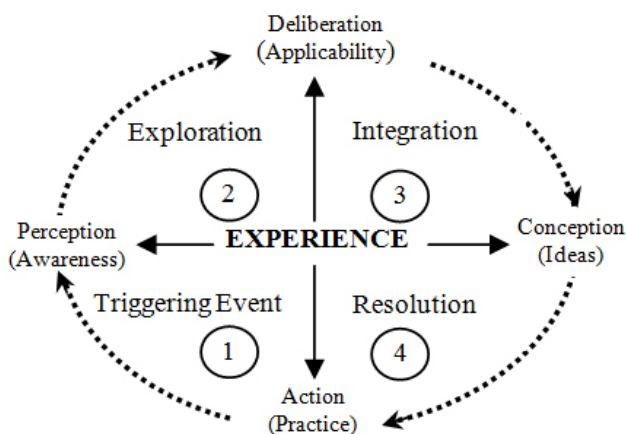

Fig.1 practical inquiry process [22]

The CoI model has proven to be useful in analysing online discussion content in order to study student learning processes during discussions (e.g. [26], [27] and [28]). Having noticed its usefulness, we adapted the model to make it more suitable to analyse discussion content in our online courses. The adapted model was evaluated and the negotiated inter-rater reliability values of the model ranged from 0.9600–1.0000 with Holsti's co-efficient, and 0.8818–1.0000 with Cohen's kappa, for discussions in the BIT courses [29]. The adapted model is used in the study reported in this paper for further analysing the discussion content of the same courses.

II. METHOD

The present study includes four steps: indentifying instructional requirements, implementing instructions, evaluating instructions and improving design principles (see Fig. 2).
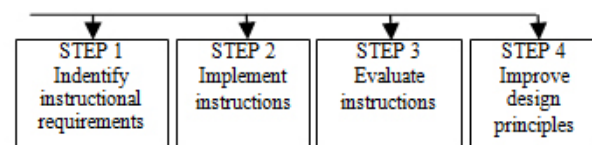

Fig. 2 design of the study

A. Procedure

Step 1: The study was initiated by collecting data via observation and conducting interviews with six instructional designers at the e-learning Centre of the University of Colombo School of Computing (UCSC). The analysis of data necessitated the requirement of proper guidelines to design inquiry-based learning activities using discussion forums. Next, a random sample of 20 discussion threads from each of the four courses was selected and analysed using an adapted CoI model [29]. The findings of the discussion content analysis were further analysed along with the course content access records in the learning management system to understand the student-content interactions during each phase of the inquiry process.

Step 2: Based on the results of the analysis in Step 1, a set of questions were prepared to gather student learning experiences and attitudes towards inquiry learning and peer-teaching. The questions were posed to a sample group of students in a design workshop.

The workshop was conducted online and it consisted of three meetings that were held in three consecutive weeks (see Fig. 3). At each meeting the students had a debriefing session and a focus group interview. The students for the workshop were invited by posting an open invitation linked to the BIT VLE. The students who expressed willingness to participate in the online workshop were invited for online meetings.
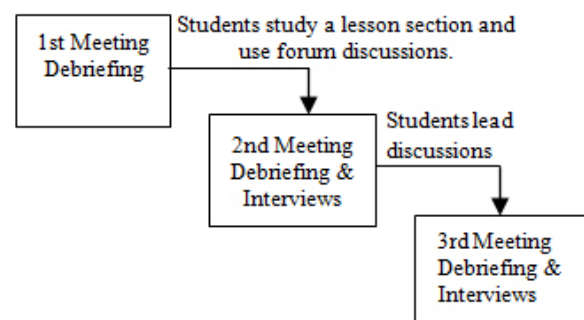

Fig. 3 meetings held at the online workshop

The pre-prepared questions were presented and answered by the students in a focus group interview at the 1st meeting. The students were instructed to engage in inquiry-based learning in the online courses during the week before the next meeting. Instructions were provided referring to [29].

At the 2nd meeting, the students' learning experiences and attitudes towards inquiry learning were collected.

Subsequently, the students were instructed to select a subject and teach it to other students via questions and answers. The students engaged in this activity during the week before the 3rd meeting.

Step 3: The 3rd meeting was held one week after the 2nd meeting. The students' satisfaction and perceived learning were evaluated to determine the effectiveness of the peer-teaching activity. Students' satisfaction was inquired by questions such as 'how do you feel about this online activity', 'were you happy to receive instructions from peers', and 'was it easier to get your problems solved by asking questions from the peers than from the facilitator. The students' perceived learning was determined by questions related to learning. For example we asked, 'were you able to learn something new', 'did you find the information that you were looking for', and 'were you able to achieve your learning objectives'.

Step 4: Based on the findings of the study, a set of design principles used to design the inquiry activity was improved. Further, for their easy application, a set of guidelines was also prepared. Implications from the findings of the present study and the contemporary research in web-based and multimedia learning design were explored to identify the design guidelines that could be recommended for instructional designers designing peer-teaching and inquiry learning activities.

B. Workshop Participants

The number of students participating in the three meetings were as follows; 13, 8 and 10. Eight students participated in all the meetings. The two students who did not participate in the 2nd meeting provided useful information at the 1st and the 3rd meetings.

Considering students' contributions at the workshops, data gathered from 10 students were analysed to answer the questions of this paper. The students belonged to the age group of 17 to 42 years of which the majority was within 17 and 24 years. The students accessed the VLE from different parts of the country. Out of the 10 students 4 students were employed. Two students - one employed and one unemployed - had decided to carry out their studies mainly using the VLE and without attending any private tuition class. One student participated in the online workshop from an e-cafe and the other students had their own wired or wireless connections to the Internet.

III. FINDINGS AND DISCUSSION

Data were analysed to identify what course components and their design features could stimulate inquiry-based learning (stimulators) and determine what kind of instructions should be given to the students to engage in peer-teaching.

### A. Stimulators for Inquiry Learning

The findings of the analysis of course content access records along with the online discussions show indications of student accesses to content outside the VLE (see Graph 1). Especially, during the exploration and the integration phases, the students referred to the content in the internet or books and articles that

were not available in the VLE. During the resolution phase, while the students in C4 referred only to the content external to the VLE, the students in C1 and C2 referred only to the content in the VLE. These access patterns pertained to the nature of the subject discipline of each course. The findings suggest that in order to motivate inquiry learning, online courses in particular C4 should provide a list of links to external learning resources and related reference materials which can be downloaded by the students. Further, going in line with our design principle, 'reuse student artefacts as resources' to design peer-teaching activity, the students said that they would like to study the discussions of students in previous batches and the resources that these students referred to in discussing problems.
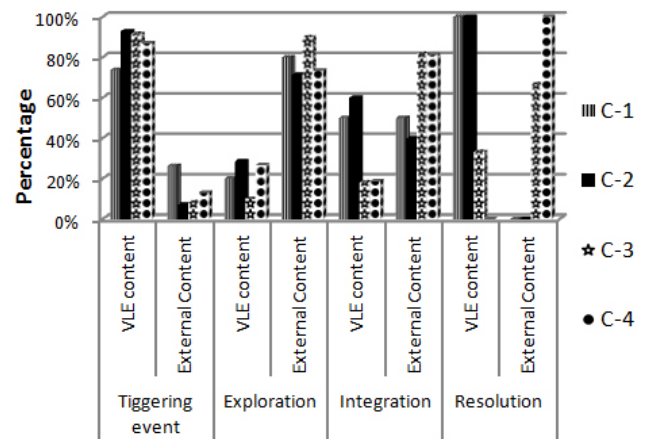
Graph 1 content accessed during the inquiry process

In order to find what course components can stimulate inquiries (triggering events) and what can support solving problems (exploration, integration and resolution) two other graphs were prepared (Graph 2 and 3). The graphs show that the students had different access patterns when they studied in different courses.
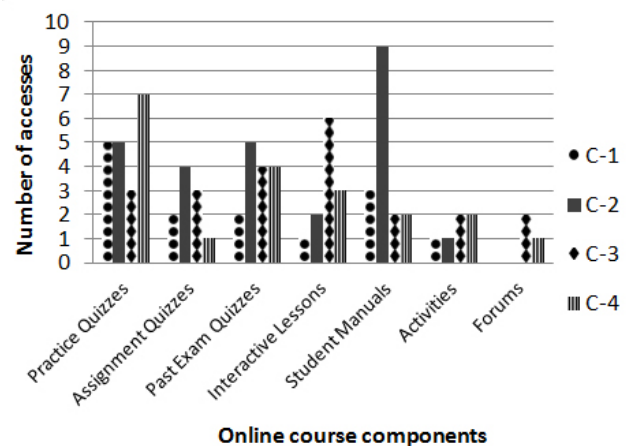
Graph 2 components causing triggering event

According to Graph2, the students in C1 and C4 attempted

practice quizzes more before posting questions (triggering event). In contrast, students in C2 referred to the student manual which was a PDF material before starting inquiries or providing solutions (see Graph 2 and 3). Comparatively, the students in C3 accessed the interactive lessons more for finding solutions to their problems or before posting questions in the discussion forums.
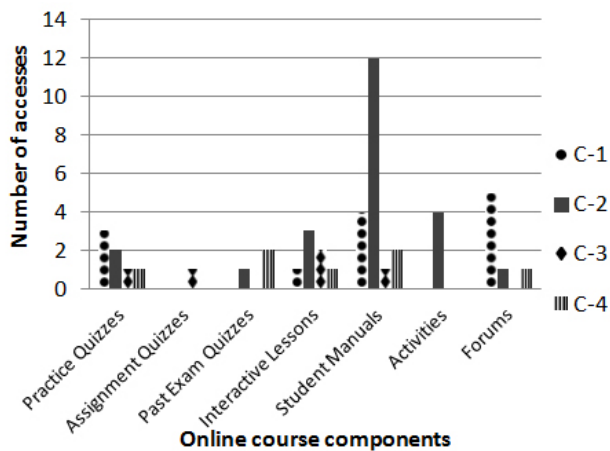
Graph 3 components accessed to solve problems

The findings suggest that in order to encourage more inquiries, quizzes in C1 and C4 should include some more challenging questions. Also, student manuals in C2, and interactive lessons in C3 should be improved with some more activities that can lead to forum discussions. The findings of the workshop affirm these suggestions. In addition, the findings of the workshop also signify that students prefer to study online more if learning content is designed with interactive animations and audio, as well as video content. This finding is in line with the contemporary research on multimedia and online learning (e.g. [30], and [31]).

Furthermore, the findings of the workshop brought about the following suggestions.

1) Add online course welcome videos - Welcome videos will introduce course environments to new students and will establish a sense of teacher presence. This will help to increase students' satisfaction towards the online courses since students like to see their teachers' faces and listen to their voices (e.g. [32] and [33]). Through a welcome video we can provide information related to a course as well as how students can regulate their own learning during the course period. In an experiment, Shen, Lee and Tsai [34], found that online students could perform better if they had received instructions in self-regulated learning before they start learning. Therefore, we believe that our suggestion to add a welcome video having information related to self-regulated learning would assist distance learners to perform better in inquiry learning where there is poor or no teacher support.

2) Improve the course components such as quizzes, student manuals and interactive lessons that can promote inquiry learning by adding more challenging questions and exercises without immediate feedback but with instructions to discuss the answers in discussion forums. Since learning is a constructive process, in order to support student learning, lesson content along with activities, quizzes, and assignments should be aligned with the course outcomes and objectives [35], [36].

3) Design a student common room - The findings of the workshop revealed that our students had a difficulty in finding or grasping the information that were provided in different media: in an introductory CD, and in the www.bit.lk web site, or in a student hand book. As a solution, the students suggested to have a separate environment in the VLE to discuss all common issues related to the four courses in the Semester. We named this environment as 'Students' Common Room' (SCR). It is a semester-level common room that can include a set of pre-course activities which students should complete before starting the respective courses in the semester. This will help to build trust and rapport among the students in the online learning environment which indeed will lead to create an online learning community [37].

4) Add pre-course activities- The findings of the present study informed that a set of pre-course activities should be designed to make students aware of course components available in the online courses, how to customise settings, how to connect with other students, tools and facilities available in the online discussion environments, the inquiry process and how to use a discussion environment. These activities can be added to the SCR. Pre-course activities are supportive for creating online learning communities [38] and as Arbaugh et al. [39] perceive, providing of pre-course activities (designing and organizing discussion environment) is one of the main roles of a teacher in a community of Inquiry. Similar findings pointing at the importance of providing introductory information and activities in inquiry-based learning have also been reported within research on mobile learning, for instance [40], [41] and [42]. Furthermore, the students noted that they would like to have online workshops with a facilitator or a mentor at the very beginning of the semester in order to solve current problems and overcome inhibitions related to active participation in online discussions. This reporting is affirmed by the findings of the present workshop since during the workshop we found that students' participation in the discussions was on a rapid increase. In order to attract more students to online courses and provide necessary information we presume that online meetings should also be conducted at the SCR. However, the information specific to individual courses needs to be provided via the welcome videos.

5) Create forums for sharing and inquiries - According to our students, there should be two separate forums –one for sharing information and the other one for inquiries – for

each lesson in a course. This will help to organize as well as to minimize the number of threads in a forum. This suggestion is supported by [43] who stated that organizing discussion space is a critical success factor for online interaction and learning.

6) Add search facility - Our students suggested that online courses should provide them a search facility to find course content quickly and easily. This needs to be introduced through learning system enhancements. A search facility would help the self-regulated learners to access quality learning content quickly and as a result students will be able to study online more efficiently. It implies that not only the components of the online course but also the facilities provided via its learning management system should be enhanced to provide a better online learning experience for students. Also, learning management system enhancements can positively influence students' satisfaction [44]. Besides, according to Snyder [37] easy accessibility of information in online learning environments can support for creating online learning communities for adult learners.

7) Improve the messaging interface- The students suggested to improve the forum interface with some additional components as shown in Fig. 4. The toolbar available in the existing interface for posting or editing messages in forum threads does not include a help button. Presently, guides to use the toolbar buttons are provided along with the other instructions and they are linked to a help icon on top of the toolbar and the message text area. It was found that the students did not go through these help instructions before attempting to post a message. Therefore at the workshop the students were asked to go through the help instructions. However, even after seeing the help instructions, the students noted that the instructions were not clear and the help was not user friendly. Also, according to our students, some of the BIT students did not know how to use the tools on the toolbar and they were afraid of trying the tools for the first time. Therefore, we decided to add a help button to the toolbar of the messaging interface and link an interactive help or guide to use the messaging interface and the toolbar.

8) In addition, the students noted that the toolbar does not support for adding auto generated messages quickly. The students suggested providing a combo box with lines of text enabling them to insert pre-formulated strings of text to the message text area. A list may include phrases or sentences such as, "Thank you.", "Sorry.", "I'll start exploring the relevant content.", "I'll try this and reply." and "Good work!" (see Fig. 4).
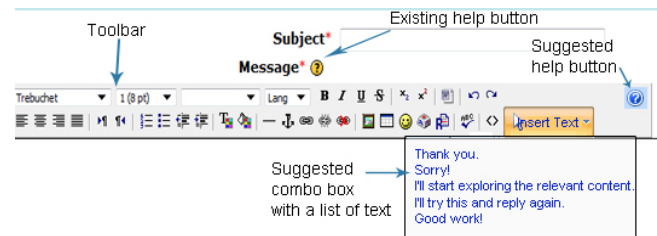

Fig. 4 Messaging interface with suggested improvements

B. Activity Instructions

At the workshop, necessary instructions to facilitate discussions and information related to inquiry learning were provided referring to [29]. The provided instructions were as follows.

1) Select a section of a topic out of the lesson sections that should be covered according to the schedules uploaded in the online courses.
2) Start a discussion thread with a meaningful subject title and an interesting question. Provide the background information of your question.
3) Adhere to the netiquettes
4) Encourage peers to explore information related to your question
5) Acknowledge others' inputs
6) Integrate information and encourage peers to integrate information provided by you and the others.
7) Motivate peers to judge and evaluate peers' responses.
8) Support your peers to resolve the problem
9) Bring in examples and experience of practical applications.
10) Try to achieve learning objectives

While doing this activity the students were also asked to participate in others' discussions as much as possible.

In the future in order to engage in peer-teaching and inquiry-learning activity, the information related to the inquiry process and how to engage in inquiry-based learning can be provided via a pre-course activity in Students' Common Room. However, students' willingness to be student leaders and play the role of facilitator in discussion environments can be inquired in 'inquiries' forum at each lesson section in an online course. Thereby, student leaders can be identified and instructions regarding the peer teaching activities; how and when to start discussions, how to facilitate peers including what they should and should not do can be provided via a private message facility in the learning management system.

C. Evaluation of instructions

In order to determine the effectiveness of the learning activity and its instructions, a set of questions were employed and the students' satisfaction and perceived learning were measured. All the students positively replied to the questions expressing their satisfaction towards the inquiry-based learning and peer-teaching activity. Also, the students' replies showed a

higher level of perceived learning. The students who played the role of facilitator and the others who could only participate in the discussions were very pleased with the peer-teaching and inquiry learning activity. These results are consistent with those of Rourke and Anderson [14] who reported that their students enjoyed peer teaching and learning from peer teams.

The evaluation results implied that we had designed the activity appropriately during the workshop. Therefore, the design principles that we used to design the peer-teaching activity were enhanced with the implications of findings in the workshop.

D. Improved Design principles and Guidelines

There were two general principles that we used to design our peer-teaching activity. They were 'engage learners in instruction of their peers' and 'reuse student artefacts as resources for further learning'. The findings with respect to the question number 1 of this study, detailed the two general principles with sets of guidelines for their easy practical application in designing peer-teaching activities as follows.

1) Engage learners in instruction of their peers –First prepare students for peer-teaching and inquiry learning and next introduce the activity. The following set of guidelines can be used to achieve these necessities.

   a. Make students aware of the inquiry process, netiquette and the discussion schedule because this information is essential for students to initiate and participate in the activity. – Supporting this idea Gagne, Wager, Golas and Keller [45] report that it is important to disseminate supportive information as prerequisites to a learning activity.

   b. Implement a strategy to select student leaders. – Some of our students were not willing to become student leaders. According to [46] voluntary leaders tend more to support peers than randomly selected leaders.

   c. Provide appropriate instructions to the student leaders. - Assign tasks and make the students aware of what they can do and what they should not do to facilitate peers; for instance they can acknowledge peer's posts but they cannot find faults with anybody for any reason. – The instructions can be provided referring to [29] and as reported in this paper. When assigning tasks, designers should keep in mind that students prefer more control over instructional options [47].

2) Reuse student artefacts as resources for further learning – According to [48], students' artefacts disseminated in a collaborative learning environment become parts of that environment and new students should have the opportunity to build on and further advance knowledge in the artefacts. Our students wanted to read useful discussions and reference materials of the students of their previous batches. In order to meet this requirement, the following guidelines were formulated.

   a. Select exemplary discussions of previous batches and make them accessible to students in the present batch and

   b. Select useful resources -may be on links- referred to by students in the previous batches, obtain permission from right parties to make them accessible via the course environments or provide the list of references.

Additionally, we considered the five instructional design issues reported by Lim [9]. Based on the findings of our study, the design issues were turned into a proposed set of design principles. Furthermore, for their easy applicability a set of design guidelines were created which are presented below.

3) Represent the inquiry process visually

   a. Illustrate the inquiry process – The students who participated in the workshop preferred to know about the inquiry process in an interactive short video or in an animation. In order to engage learners in a learning activity we have to find a better way of presenting, representing and visualizing the information that we need to communicate [49].

   b. Make sure it provides a clear and concise description of the inquiry process – Text and graphics can be designed adhering to the recommendations provided in [47]. Too much of information presently linked to the help icon on the messaging interface seemed to have created a tendency to ignore the message help.

4) Provide appropriate instructions to students in order to motivate their peers with the right questions –Lim [9] claimed that students should be motivated with right questions. For this purpose, we provided the student leaders instructions that were required to raise motivational questions in the discussion forums. It was done in two steps as follows;

   a. Review the inquiry process through questions and answers –Make sure whether students knew the inquiry process. - and

   b. Provide a set of sample questions that students can ask their peers at each phase of the inquiry process

5) Provide activities that usually students do when engaging in inquiry-based learning –This can help learner to remember the information as well to develop the skill of problem solving and completing concrete tasks [50]. The following set of guidelines was formulated considering the requirements of our students.

   a. Provide a set of exercises for students to practise creating, editing, and deleting messages

   b. Describe how to upload files and add pictures to their messages

   c. Make students aware of how to customize settings of the student profiles to receive forum messages to their e-mail addresses.

6) Design tools that can guide students in the inquiry process – The descriptions in the Help on the message interface seemed not supportive for the students and they suggested certain requirements that are stated in the following guidelines.

a. Design interactive guides/helps to demonstrate how to create and send messages and how to participate in inquiry-based learning –Including interactive rather than static content can motivate learners to be more active in online learning [51].

b. Provide tools to post questions that students might often use in their discussions and

c. Create drop down lists with frequently used expressions, helps and guides to use tools and facilities available in the discussion environment – Not only the instructions but also the tools that used to prepare and send messages should be improved to enhance students' inquiry-based learning experience.

7) Facilitate the students with resources and tools required for engaging in inquiry-based learning and build up a community of inquiry

a. Prepare the recommended text for downloading and make it suitable for offline reading – This is necessary in order to support students with poor internet connections.

b. Improve the course components such as activities, quizzes, manuals and interactive lessons that can promote inquiry learning according to the findings of the present study.

c. Add social networking facilities –Social presence is one of the three essential elements of a community of inquiry [52]. Learners in social communication platforms even have tended to use a special language form called Netspeak [53]. In order to support online discussions, in particular for net speaking, the students suggested that social networking facilities in the VLE should be improved.

d. Enhance both asynchronous and synchronous communication facilities provided via online course environments because each has its own particular advantage for learning in online learning environments [54].

We believe that the improved set of design principles and guidelines can be best applicable for designing peer-teaching activities to promote inquiry learning in online learning environments prepared for distance education programmes on information and communication technology related subjects.

IV. CONCLUSION

Peer-teaching and inquiry-based learning have long been practised as two teaching and learning approaches. The present paper discussed instructional design principles and guidelines to design a learning activity blending the two approaches and assigning teaching role to learners. This will create more opportunities for challenges, criticism, comments, suggestions, and questions for students at distance and in online learning. The students may tend to show their talents by presenting the content in different ways and this tendency may possibly motivate students to participate in online discussions. However, designers of online learning environments and other educational practitioners cannot expect all students to participate in course discussions because students have their own learning preferences and styles that are more suitable to carry on their studies. Therefore, in order to increase students' active participation in discussions, designers cannot make discussion activities compulsory for students. However, if discussion environments are designed with appropriate instructional design principles and guidelines as the authors have discussed in this paper to welcome students, guide them how to use the environment and keep them engaged in discussions, then more and more students may possibly tend to participate in discussions. Future research studies are welcome for further investigation in affirming this reasoning.

APPENDIX

Table 1 cognitive presence coding scheme of the CoI model [29]

Phase	Descriptor	Code	Indicators	Socio-cognitive process	Examples (T1,...,Tn are triggering events and T1→,...,Tn→ are replies to the issues raised at the triggering eventsT1,..,Tn respectively.)
Triggering event (C-TE)	Evocative • Stimulate one's curiosity • Core organizing concept or problem that learners can relate to from their experience or previous studies • Framing the issue and eliciting questions or problems that learners see or have experienced • Assessing state of learners knowledge and generating unintended but constructive ideas	C-TE1	Recognizing problem	Presents background information that may culminate in a question or presents a problem/issue.	• "In section 5, page 152 of the student manual says 'solid states'... Could you please explain what it means?" • "I think the statement 'the Internet uses TCP standards in data transmission' is correct. But in a Quiz, it is considered as incorrect. Can it be a mistake? Please explain."
		C-TE2	Sense of puzzlement	Questions or messages that take the discussion in a new direction.	• "Sometimes ago, I studied what 'bit' and 'byte' are. But now, I can't remember and I am confused. Can someone explain what they are?" • "I wanted to print cell borders of a Calc worksheet. But failed. Is there anybody who has done it before?" • "Are touch-screen laptops better than normal laptops?"

Exploration (C-EX)	Inquisitive • Understand the nature of the problem and then search for relevant information and possible explanation • Group activities-brainstorming • Private activities-literature searches • Manage and monitor this phase of divergent thinking in such a way that it begins to be more focused	C-EX1	Exploration within the online community	Unsubstantiated agreement or disagreement/contradiction of previous ideas.	T2 → • "I don't agree. It is incorrect." • "I agree with you."
		C-EX2	Exploration within a single message	Many different ideas/themes presented in one message.	T1 → • "Dictionary meaning of 'solid state' is.... In a past exam paper I found it defined as '...' But I have been taught it as '...'"
		C-EX3	Information exchange	Personal narratives or descriptions (not necessarily regarding personal experiences) or facts (i.e., from sources such websites, articles, programmes, etc.) Adds points but does not systematically defend/justify/develop addition.	T4 → • "http://www..... This online video might help you to understand how to print cell borders."
		C-EX4	Suggestions for consideration	Author explicitly characterizes message as exploration	T3 →[After bringing out some information about bit and byte] • "Does that seem about right?" • "Am I way off the mark?"
		C-EX5	Leaping to conclusion	Offers unsupported opinions	T2 → • "...It's a mistake." T4 → • "Cell borders of a worksheet cannot be print."
Integration (C-IN)	Tentative • Focused and structured phase of making meaning • Decisions are made about integration of ideas	C-IN1	Integration among group members	Reference to previous message followed by substantiated agreement or disagreement. Building on, adding to others' ideas.	T2 → • "I don't agree with you because..." • "I agree because..." • "According to what Renuka noted, ... But I think ..."
		C-IN2	Integration within a single message	Justified, developed, defensible, yet tentative hypotheses.	T4 → • "I used this free tutorial, http://.... It explains how to print worksheets with cell borders. According to that, first you have to ...."
		C-IN3	Connecting ideas	Integrating information from one or more sources – textbooks, articles, personal experience, other posts or peer contribution.	T5 → • "As Neel said, now there are laptops with touch screens. See the attached picture. But there is a problem with these laptops. Read this, http://... Therefore, I think..."
		C-IN4	Creating solutions	Explicit characterization of message as a solution by participant.	T4 → "Here is the answer; you can print cell borders like this... Format>Page>Sheet tab>..."
Resolution/ application (C-RA) (C-RA)	Committed • Reducing complexity by constructing a meaningful framework or discovering a contextually specific solution • Confirmation or testing phase may be accomplished by direct or vicarious action.	C-RA1	Vicarious application to real world testing solutions	Providing examples of how problems were solved or evidences of successful application.	T4 → • "How I printed a Calc worksheet with cell borders was..." • "It did not work at first. But when I selected some lines of text and tried again then it worked..."
		C-RA2	Defending solutions	Defending why a problem was solved in a specific manner.	T4 → • "Here is the modified list of steps to print a worksheet with cell borders. I did a small change to the second step of Mahela's procedure. Because I could not open the Print dialog box by following it as it was."

• Resolution of the dilemma or problem	C-RA3	Judging or evaluating and expressing satisfaction	Judgment or evaluation followed by an expression of satisfaction after solving the problem or issue that caused the triggering event.	T1 → • "...I understood what 'solid state' means. Thanks." T2, T3, T5 → • "...Thanks for the explanation. I got my doubt cleared/ problem solved." T4 → • "...Thanks a lot. I followed your instructions and printed a worksheet with cell borders."

REFERENCES

[1] N. A. Whitman and J. D. Fife, "Peer teaching: to teach is to learn twice," in *ASHE-ERIC Higher Education Report,* no. 4, 1988, ASHE-ERIC Higher Education Reports, The George Washington University, One Dupont Circle, Suite 630, Dept. RC, Washington, DC 20036-1183, 1988.

[2] K. J. Topping, "Trends in peer learning," *Educational psychology,* vol.25, no.6, 2005, pp.631-645.

[3] T. Smith, *Undergraduate Curricular Peer Mentoring Programs: Perspectives on Innovation by Faculty, Staff, and Students.* Lexington Books, 2012.

[4] S. Järvelä, P. Häkkinen, M. Arvaja and P. Leinonen, "Instructional support in CSCL," In *What We Know About CSCL*, Springer Netherlands, 2004, pp. 115-139.

[5] D. R. Garrison and M. Cleveland-Innes, "Facilitating cognitive presence in online learning: interaction is not enough," *American Journal of Distance Education,* vol.19, no.3, 2005, pp.133-148.

[6] R. Oliver, "Engaging first year students using a web-supported inquiry-based learning setting," *Higher Education,* vol.55, no.3, 2008, pp.285–301.

[7] C. McLoughlin and J. Luca, "Cognitive engagement and higher order thinking through computer conferencing: we know why but do we know how," *In* 2000 *Proc. of the 9th Annual Teaching Learning Forum,pp.2-4.*

[8] C. Kai-Wen, "Web-based design model for situated learning in accounting education," *WSEAS Transactions on Advances in Engineering Education*, vol. 10, no.1, 2013, pp.48-59.

[9] B-R. Lim, "Challenges and Issues in Designing Inquiry on The Web," *British Journal of Educational Technology,* vol.35, no.5, 2004, pp.627–643.

[10] I. Kollar, F. Fischer and J. D. Slotta, "Internal and external scripts in computer-supported collaborative inquiry learning," *Learning and Instruction,* 2007, vol.17, no.6, pp.708-721.

[11] T. Anderson, "Getting the mix right again: an updated and theoretical rationale for interaction," *The International Review of Research in Open and Distance Learning,* vol.4, no.2, 2003, pp.1-14.

[12] T. A. Weerasinghe, R. Ramberg, and K. P. Hewagamage (2012), Inquiry-based learning with or without facilitator interactions. *The Journal of Distance Education/Revue de l'Éducation à Distance* [Online]. 26(2). Available: http://www.jofde.ca/index.php/jde/article/view/779.

[13] C. D. Wickstrom, "A" Funny" thing happened on the way to the forum," *Journal of Adolescent & Adult Literacy*, vol.46, no.5, 2003, pp.414-423.

[14] L. Rourke and T. Anderson, "Using peer teams to lead online discussions," *Journal of interactive media in education,* vol.1, 2002.

[15] S. I. Park and S.Y. Jang, "Analysis of peer-scaffolding patterns in four phases of problem-solving in web-based instruction," *The SNU Journal of Education Research,* vol.17, 2008, pp.1-31.

[16] P. Toth, "Online learning behavior and web usage mining," *WSEAS Transactions on Advances in Engineering Education*, vol. 10, no. 2, 2013, pp. 71-81.

[17] G. Kanselaar, "Constructivism and socio-constructivism," *Constructivism and Socio-constructivism,* 2002, pp.1-7.

[18] G. O'Neill and T. McMahon, "Student-centred learning: what does it mean for students and lecturers?" *Emerging issues in the practice of university learning and teaching*, vol.1, 2005.

[19] Y. Kali, R. Levin-Peled and Y. J. Dori, "The role of design-principles in designing courses that promote collaborative learning in higher-education," *Computers in Human Behavior*, vol. 25, no.5, 2009, pp.1067-1078.

[20] K. G. Arvanitis, G. Patelis, D. Papachristos, Application of a model of asynchronous web based education (WBE) in the agricultural engineering sector," *WSEAS Transactions on Advances in Engineering Education*, vol.9, no.1, 2012,pp. 12-22.

[21] V. Buraphadeja and K. Dawson, "Content analysis in computer-mediated communication: analyzing models for assessing critical thinking through the lens of social constructivism," *American Journal of Distance Education,* vol.22, no.3, 2008, pp.130-145.

[22] D. R. Garrison, T. Anderson, and W. Archer, "Critical inquiry in a text-based environment: computer conferencing in higher education," *The Internet and Higher Education,* 1999, vol. 2, no. 2, pp. 87-105.

[23] D. R. Garrison, T. Anderson, and W. Archer (2001, April). Critical Thinking and Computer Conferencing: A Model and Tool to Assess Cognitive Presence, [Online]. Available: http://auspace.athabascau.ca:8080/dspace/bitstream/2149/740/1/critical _thinking_and_computer.pdf.

[24] Z. Akyol and D.R. Garrison, "Assessing Metacognition in an Online Community of Inquiry," *The Internet and Higher Education*, vol.14, no.3, 2011, pp. 183-190.

[25] Dewey, J. (1997). *How We Think.* Courier Dover Publications.

[26] J. B. Arbaugh and A. Hwang, "Does 'teaching presence' exist in online mba courses," *The Internet and Higher Education,* vol.9, no.1, 2006, pp.9-21.

[27] P. Shea, S. Hayes, J. Vickers, M. Gozza-Cohen, S. Uzuner, R. Mehta, ... & P. Rangan, "A re-examination of the community of inquiry framework: social network and content analysis," *The Internet and Higher Education,* vol.13, no.1, 2010, pp.10-21.

[28] K. Swan and P. Ice, "The community of inquiry framework ten years later: introduction to the special issue," *The Internet and Higher Education,* vol.13, no.1, 2010, pp.1-4.

[29] T. A. Weerasinghe, K. P. Hewagamage and R. Ramberg, "re-evaluation of community of inquiry model with its metacognitive presence construct," *International Journal on Advances in ICT for Emerging Regions,* vol.5, 2012, pp. 1-13.

[30] T. juang Wang, "Educational benefits of multimedia skills training," *TechTrends*, vol.54, no.1, 2010. pp. 47-57.

[31] S. H. R. Wong, "Incorporating audio-visual materials in university teaching: results of a faculty survey and corresponding actions of the library," *New Review of Academic Librarianship*, vol.15, no.1, 2009, pp.35-52.

[32] P. Suanpang, P. Petocz and A. Reid, "Relationship between learning outcomes and online accesses," *Australasian Journal of Educational Technology, v*ol.20, no.3, 2004, pp.371-387.

[33] B. Kerr, "Design Preferences for and Attitudes Concerning E-Learning in a Global Organization," Ph.D. dissertation, Concordia University, 2012.

[34] P. D. Shen, T. H. Lee and C. W. Tsai, "Applying web-enabled problem-based learning and self-regulated learning to enhance computing skills of taiwan's vocational students: a quasi-experimental study of a short-term module," *Electronic Journal of e-Learning,* vol.5, no.2, 2007, pp.147-156.

[35] J. Biggs, "Aligning teaching for constructing learning," *Higher Education Academy,* 2003.

[36] J. Biggs and C. Tang, *Teaching for Quality Learning at University.* Open university press, 2011.

[37] M. M. Snyder, "Instructional-design theory to guide the creation of online learning communities for adults," *TechTrends,* vol.53, no.1, 2009, pp.48-56.

[38] S. Renzi and J. E. Klobas, "Developing community in online distance learning," *ECIS*, 2002, pp. 1384-1393.

[39] J. B. Arbaugh, M. Cleveland-Innes, S. R. Diaz, D. R. Garrison, P. Ice, J. C. Richardson and K. P. Swan, "Developing a community of inquiry instrument: testing a measure of the community of inquiry framework using a multi-institutional sample," *The Internet and Higher Education,* vol.11, no. 3, 2008, pp. 133-136.

[40] J. Eliasson, T. C. Pargman, J. Nouri, D. Spikol, and R. Ramberg, "Mobile devices as support rather than distraction for mobile learners: evaluating guidelines for design," *International Journal of Mobile and Blended Learning (IJMBL)*, vol.3, no.2, 2011, pp.1-15.

[41] J. Eliasson, and R. Ramberg, "Design guidelines for location-based and contextual learning supported by mobile devices," *International Journal of Handheld Computing Research (IJHCR),* vol.3, no.2, 2012, pp.26-43.

[42] J. Nouri, T.C. Pargman, J. Eliasson and R. Ramberg, "Exploring the challenges of supporting collaborative mobile learning," *International Journal of Mobile and Blended Learning*, vol.3, no.4, 2011, pp.54-69.

[43] A. H. Galvis, "Critical success factors implementing multimedia case-based teacher professional development," *La Educ@ ción XLVII-XLIX,* 2004, pp.139-140.

[44] R. Rahamat, P. M. Shah, R. Din, S. N. Puteh, J.A. Aziz, H. Norman, M. A.Embi, "Measuring learners' perceived satisfaction towards e-learning materials and environment," *WSEAS Transactions on Advances in Engineering Education*, 2012, vol. 9, no. 3, pp. 72-83.

[45] R. Gagne, W. W. Wager, K. C. Golas and J. M. Keller, *Principles of Instructional Design.* Thomson Wadsworth, Belmont, CA, 2005.

[46] S. Centorrino and L. A. Concina, *Competitive Approach to Leadership in Public Good Games* (No. 13-383). Toulouse School of Economics (TSE), 2013.

[47] R. C. Clark and R. E. Mayer, *E-learning and the Science of Instruction, Proven Guidelines for Consumers and Designers of Multimedia Learning.* Wiley, Com, 2011.

[48] R. Levin-Peled, Y. Kali and Y. J. Dori, "Promoting collaborative learning in higher education: design principles for hybrid courses," *In 2007 Proc. of the 8th International Conference on Computer Supported Collaborative Learning*, pp. 421-430.

[49] N. Shedroff, *Experience Design 1.1 a Manifesto for the Design of Experiences*. Experience Design Books, 2009.

[50] M. D. Merrill, "First principles of instruction: a synthesis," *Trends and Issues in Instructional Design and Technology*, vol.2, 2007, pp. 62-71.

[51] V. Fedulov, "Educational Evaluation of an Interactive Multimedia Learning Platform: Computerized Educational Platform in Heat and Power Technology," Ph.D. dissertation, KTH, 2005.

[52] D. R. Garrison, "Online community of inquiry review: social, cognitive, and teaching presence issues," *Journal of Asynchronous Learning Networks*, vol.11, no.1, 2007, pp.61-72.

[53] K. Aleksic-Maslac, T. Djuras and J. P. Darrer, "Netspeak standards: measuring the quantity within the closed asynchronous discussions," *WSEAS Transactions on Advances in Engineering Education*, 2013, vol. 10, no. 1, pp. 60-69.

[54] S. Hrastinski, "Asynchronous and synchronous e-learning," *Educause quarterly*, vol.31, no.4, 2008, pp.51-55.

Thushani A. Weerasinghe is a lecturer at the University of Colombo School of Computing, Sri Lanka. She has experience in designing and delivering online courses. Presently, she is doing her PhD studies at the Stockholm University, Sweden. She completed her Licentiate of Philosophy degree in 2009.

Robert Ramberg is a professor at the department of computer and systems sciences at Stockholm University, Sweden. He has published numerous articles in journals and refereed conferences and acted as a reviewer for several international journals within technology enhanced learning.

K. P. Hewagamage obtained his Doctor of Information Engineering from Hiroshima University. He has more than 80 publications in International peer reviewed journals and conference proceedings. He is a senior lecturer at the University of Colombo School of Computing, Sri Lanka and senior member of IEEE.