THE COMMUNITY OF INQUIRY MODEL TRAINING USING THE COGNITIVE APPRENTICESHIP APPROACH TO IMPROVE STUDENTS' LEARNING STRATEGY IN THE ASYNCHRONOUS DISCUSSION FORUM

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ABSTRACT

An online discussion forum has the potential to facilitate collaborative learning that improves students' critical thinking. To explain the collaborative online learning experience, the Community of Inquiry (CoI) model has been proposed by a group of researchers. The model captures an in-depth and meaningful collaborative online learning process as the dynamics of social presence, cognitive presence, and teaching presence. Experts agree that collaborative learning using an online discussion forum requires different skills as compared to face-to-face learning activities. Currently available research on how to develop e-learning skills is still limited. This study aims to propose a training strategy of the CoI model by using the cognitive apprenticeship approach. The training is integrated with Linear Algebra classes involving 89 first-year Computer Science students at a large public university in Indonesia. The students were divided into two classes, each designed with a different learning experience. The metacognitive ability of students with the CoI training increased. They were exposed to the different learning strategies of other participants, which encouraged them to change their own strategy if needed. There was no significant change of metacognitive ability in the students who did not participate in the training. The average scores of the midterm and final exams of both classes did not differ significantly; however, students with the CoI training gave better answers to open questions that required them to argue their answer.

Keywords: community of inquiry, cognitive apprenticeship, online discussion forum

INTRODUCTION

Experts agree that online collaborative learning has the potential to improve students' critical thinking. The lag time in an asynchronous discussion forum allows participants to think critically. Discourse in an online discussion forum can be properly recorded so that it can be re-read and analyzed more deeply. As compared to discussions

held orally, written ideas can be grasped more fully as they can be read at the readers' own pace. Meaningful critical online discussion requires careful planning because online interaction demands different skills as compared to face-to-face communication. To create a collaborative online learning experience that fosters critical thinking, Garrison, Anderson, and Archer (1999) proposed the Community of Inquiry (CoI) framework. The CoI framework explains that a meaningful critical discourse in online learning occurs through reciprocal interaction among cognitive presence, social presence, and teaching presence.

The CoI framework describes the processes involved in knowledge building in asynchronous learning as the dynamics of various presences. Hence, the model has been implemented in various contexts and cultural backgrounds. The use of the CoI instrument to study the impact of instructional designs and domains in an asynchronous online discussion forum has attracted the attention of researchers and educators. An asynchronous online discussion forum can be utilized and optimized to facilitate interactions among students and between students and instructors in an online learning session. From the perspective of infrastructure, this approach is still relevant and significant in developing countries where Internet bandwidth is limited.

To project oneself socially as a "real person" (social presence), take an active role as members of a learning community, and apply critical thinking in online discussion forums requires different skills as compared to face-to-face sessions. The sense of presence in an online discussion forum does not occur naturally; it should be planned and managed earnestly. Available research on how to develop online collaborative learning skills is still limited.

Previous studies on how to prepare students with the Community of Inquiry model were conducted by Boris and Hall (2005) and Santoso (2014). Kasiyah (2017) and Junus et al. (2017) introduced a CoI model training strategy using cognitive apprenticeship. The study reveals that social presence is most easily taught because it is instantly felt, easy to emulate, and does not require deep thinking (Junus et al., 2017). Junus, Sadita, and Suhartanto (2014) showed that the teaching presence will be high when students have a responsibility for the continuity of the discourse. This can be created by dividing the class into small groups and giving each of them clear learning targets. In contrast to social and teaching presences, cognitive presence requires more effort to learn.

This study focuses on promoting cognitive presence without ignoring social and teaching presences. The purpose of this study is to propose a training strategy of the CoI model focused on the cognitive presence in a collaborative online learning environment. The training was designed to meet learners' needs, reflected by their level of e-learning readiness (Junus et al., 2017). The training employs the cognitive apprenticeship approach. Students learn how to exhibit social, teaching, and cognitive presences by observing the lecturers/facilitators, then practice the skills under the guidance of the lecturers/facilitators and apply them to complete given tasks.

RELEVANT LITERATURE REVIEW

An online discussion forum has the potential to facilitate collaborative learning that enhances critical thinking skills (Gokhale, 1995; Lim, Cheung, & Hew, 2011; Walker, 2005). Asynchronous discussion forums allow participants to think deeply because the content of the online discussion forum is recorded; hence, it can be re-read, studied, and further analyzed in-depth. Compared to oral discussions, submission of written ideas can be grasped and understood by the readers more fully.

Before writing down ideas, learners need to think about their own understanding and organize their thoughts, and then present it in a form that can be understood by readers. During the process, the learners monitor and assess their own understanding, making them more aware of their thinking process. Sharing ideas in text enhances an individual's ability to draw up arguments sequentially and logically (Gokhale, 1995). Palloff and Pratt (2005) emphasized the importance of collaboration in learning because of its potentials to foster and nurture the development of critical thinking skills and to support the construction of knowledge through reflection and transformative learning.

Garrison et al. (1999) introduced the CoI model, which is useful for guiding instructors in designing the online collaborative learning experience. The model constitutes three interrelated elements essential for meaningful and critical discussion:

social presence, teaching presence, and cognitive presence. It outlines the processes involved in the construction of knowledge in asynchronous learning environments through the dynamics of social, teaching, and cognitive presences (Shea & Bidjerano, 2012).

Cognitive presence is operationalized by the Practical Inquiry Model (Garrison et al. 1999). It describes the process of constructing knowledge collaboratively as a continuous process that begins with triggering events marked by the emergence of problems that encourage exploration, followed by integration/synthesis of ideas to attain solutions that can be applied to other contexts (resolution). In some studies, such as Richardson and Ice (2010), this model is used to measure the critical thinking level of triggering events (level 1), exploration (level 2), integration (level 3), and resolution (level 4).

The CoI framework helps researchers conceptualize the complex interactions among learners in online learning (Conrad, 2008). The CoI model has been widely adopted because it provides a theoretical basis and best practices regarding online learning experiences (Garrison & Akyol, 2013). Ice (2008) believed that the CoI model provided tools to investigate the effect of strategies and technologies in online learning. The CoI framework and the conceptualization of each component have been tested for validity by experts (Arbaugh & Hwang, 2006; Díaz, Swan, Ice, & Kupczynski, 2010; Garrison & Arbaugh, 2007; Garrison & Cleveland-Innes, 2005). The framework has attracted a lot of attention from researchers and e-learning instructors; however, the CoI framework is not yet well-known in Indonesia. Applying the framework at a large public university in Indonesia is a challenge because students come from a variety of cultural backgrounds. Research reports on the application of the CoI framework within the context of Asia are still limited, as most reports are dominated by North American, European, and Australian researchers (Befus, Cleveland-Innes, Garrison, Koole, & Vaughan, 2014).

A learning environment with the CoI framework demands the ability of the participants to interact with e-learning community through social, cognitive, and teaching presences. Besides the ability to work collaboratively within e-learning community, essential e-learning competencies include managing of the e-learning environment and interacting with learning content (Parkes, Reading, & Stein, 2013). Successful online learning requires students to have self-discipline and self-regulation (van Rooij & Zirkle, 2016). For the beginners of online learning, skills to apply social, cognitive, and teaching presences are not sufficiently taught through explanation only. Students need to observe, practice, and apply the skills in dealing with real problems. Creating social, cognitive, and teaching presences are the results of the awareness, understanding, and engagement through experiences. The cognitive apprenticeship method provides opportunities for learners to observe and practice skills (Collins, 2006). Apprenticeship is a learning process through which a more experienced person assists learners by way of modelling, coaching, and providing examples (Collins et al., 1989). Cognitive apprenticeship is defined as an apprenticeship process that utilizes cognitive and metacognitive skills and processes to guide learning (Collins, Brown, & Newman, 1989). It is an active learning that takes place in an authentic domain. Cognitive apprenticeship activities include modelling, explanation, coaching, scaffolding, reflection, articulation, and exploration. Four key concepts are closely related to cognitive apprenticeship: situated learning, legitimate peripheral participation, guided participation, and engagement in a community of practice (Dennen & Burner, 2008).

Manlove, Lazonder, & De Jong (2006) asserted that an online discussion forum is a collaborative space where mutual regulation (coregulation) occurs. Coregulation in an online discussion forum appears in the forms of explaining, asking questions, directing, and providing feedback. Research on the role of metacognition in learning has been widely carried out; among others, Saab (2012) shows a positive correlation between the ability of students to regulate themselves and their learning attainment. Magno (2010) concluded that metacognition is a predictor of critical thinking. When the learner can control the cognitive process, they can then become more critical. Within the CoI framework, metacognition is an intersection between cognitive and teaching presences (Garrison et al., 1999). Metacognition involves a reciprocal relationship between the formations of reflective knowledge (internal) with the collaborative learning activity. Metacognition mediates between the formations of

individual knowledge in a collaborative learning environment (Garrison & Akyol, 2013).

Metacognition not only occurs when individuals interact with the learning content, but it also includes interactions with other people (Kim, 2013). Garrison and Akyol (2013) address the need for a construct to understand individual metacognition in a collaborative learning environment. If learners are actively involved in constructing knowledge, then they need to regulate themselves (self-regulation) and share with other people's regulations (coregulation). Self-regulation is a phase undertaken in directing learners to reflect on their own thoughts in completing tasks; coregulation in learning is how individuals interact with other participants to achieve common goals (Garrison & Akyol, 2013). Dinsmore, Alexander, and Loughlin (2008) argue that self-regulation cannot happen without the interaction of individuals with their environment.

METHOD

Research Questions

The objective of this study was to propose a training method to improve students' ability as members of a learning community based on the CoI framework. The study was guided by the following research questions:

(1) How to design CoI training to improve students' critical thinking?

(2) What is the impact of the training on students' self-regulation and coregulation?

Research Design

This study was done throughout a Linear Algebra class conducted in a blended learning environment. The online class was run in SCELE (Student-Centered E-Learning Environment), a learning management system developed by the E-learning Team of Faculty of Computer Science of Universitas Indonesia. The Moodle (Modular Object-Oriented Dynamic Learning Environment) is used as the core of SCELE (Hasibuan & Santoso, 2005). The Linear Algebra class utilized the discussion board for an asynchronous discussion forum.

Students were grouped into two classes: Class A and Class B. Both classes were conducted in parallel using the blended-learning approach with the same learning modules. Class A students received CoI training for the first five weeks. Whereas, the use of the online discussion forum in Class B focused on frequently asked questions and announcements. Figure 1 shows the research design of the study.

A preliminary study was conducted to identify students' online learning readiness (Junus et. al., 2017). The online learning readiness questionnaire and the metacognitive questionnaire were given to all participants before training began. The data were collected and prepared for a preliminary study, which was used to examine the students' preparedness in collaborative online learning and initial disposition. The training strategy was designed to meet students' characteristics.

The same metacognitive questionnaire was distributed to students at the end of the course (posttest). The responses to the pretest and posttest were compared to investigate the impact of the training on students' learning. The transcripts of the online discussions conducted after the training were collected to investigate how students exhibit cognitive presence and how they implement triggering events, exploration, integration, and resolution. An in-depth survey conducted at the end of the following semester aimed to investigate how students apply their discussion skills in different courses. Mixed methods were applied to analyze the qualitative and quantitative data. The research design is presented in the Figure 1.

Participants

Participants were students enrolled in the Linear Algebra course during the 2016 academic year. It is a compulsory course offered for freshman students. The students came from various parts of Indonesia. As first-year students, their academic experiences at a university learning environment are all similar. We choose this course because it covers topics requiring students to apply critical thinking to change their understanding (accommodation), and the faculty team has extensive experience in teaching this course using blended learning. Initial studies were conducted in the course of the previous academic year (Junus et al., 2015). Collaborative learning using an online discussion board is a new learning experience for most students. A total of 89 students participated in this study. Class A consisted of 63 students, and Class B consisted of 26 students.

As institution policy, if a course is offered in more than one parallel class, students are

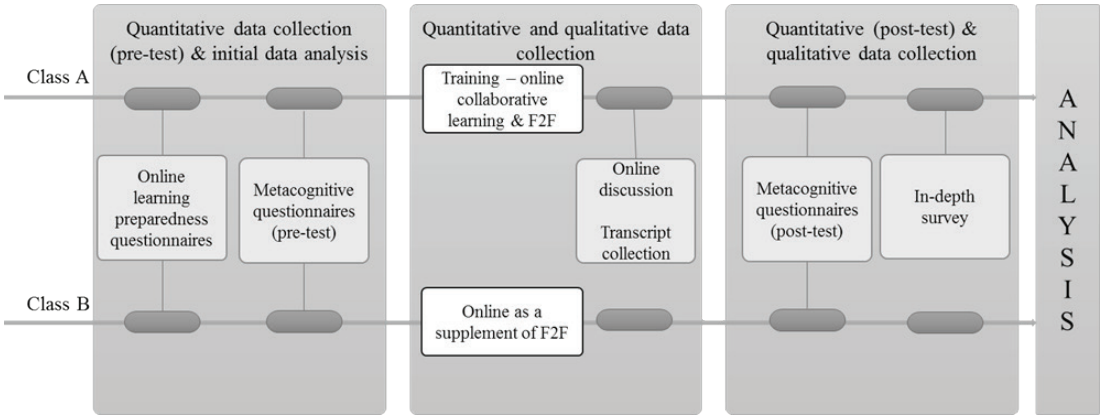

Figure 1. The Research Design

Table 1. Summary Statistics of Class A and Class B

Mean	$\bar{x}_A$	$\bar{x}_B$	Statistics
GPA	3.375	3.3887	Z=0.3345
Person mean measures of the students' e-learning competency questionnaire data	1.19	1.65	p-value=0.064
Person mean measures of the metacognitive questionnaire data	1.01	0.89	Z=0.5809

Note. Regarding the in-depth survey, the authors of this article created the questions.

given the right to choose which one they prefer. Therefore, randomization of samples cannot be done. However, in terms of the students' average GPAs and the participants' mean measures of the metacognitive and preparedness questionnaires, students of Classes A and B are not significantly different (see Table 1).

Training Design

The training was preceded by a preliminary assessment of students' readiness in online learning and metacognition. The preliminary study was taken into consideration in the design of the training. The preliminary study indicated that students can use learning technology adequately; they have moderate ability to interact with learning content, but they are less able to interact with other participants in the online learning environment or initiate the discussion and help others learn. Some students said that collaborative online learning was new for them, and they suggested the need to give them additional time for adaptation. Other students said they were not sure about language usage. These confirm that the students need training to understand the importance of collaborative learning and to develop skills in social, teaching, and cognitive presences.

Objective of the Training

The training aims to prepare students to be active participants in a collaborative online learning environment by way of social, teaching, and cognitive presences. The training is integrated with the first four topics of the course in such a way that both training and learning objectives are attained. In high school, students are introduced to the core content of the first four topics: linear systems, matrix algebra, determinant, and vectors in two and three-dimensional spaces. The next topics, general vector space and inner product space, are new for students and require them to apply more learning strategies and critical thinking. The training is integrated with familiar topics so they can focus on both the content and learning process; hence, the learning and training objectives are accomplished simultaneously.

Table 2. Instrumentation

Instrument	Criteria/Themes	Author
Metacognitive questionnaire	• The role of a participant as an individual • The role of a participant as a member of the learning community	Garrison & Akyol (2013)
Transcript analysis based on the coi model	• Social presence, cognitive presence, teaching presence • Triggering event, exploration, integration, resolution	Shea et al. (2010)
In-depth survey	• Technical obstacles • A new experience • Generalizability • Main challenges • Benefits	

Student Characteristics

A preliminary study was conducted to investigate the students' readiness in e-learning and metacognition. The e-learning competency questionnaire and metacognitive questionnaire were given to students prior to the training. The findings suggest that students are disposed to becoming open-minded, they recognize lecturers' roles as facilitators, they are well-prepared to use the technology of e-learning, and they have moderate competencies in interaction with content. However, they have low competency in navigating a large amount of information, determining the relevance of the information, and comparing several resources for accuracy. Students are not well-prepared in a number of areas such as self-discipline, including time management, initiating interaction with other participants, challenging the strategy of others, observing the strategy of others, helping others learn, and assessing the level of their own understanding.

Training Topics

The students were new to online collaborative learning and the active learning approach, and since the CoI framework, by nature, is student-centered, the training included the meaning and importance of critical thinking, the importance of active learning, the challenges of online interaction, and how to exhibit and apply social, teaching, and cognitive presences in an online discussion. Cognitive presence consists of four phases of practical inquiry: triggering event, exploration, integration, and resolution.

Training Methods

A cognitive apprenticeship approach was applied to run the training in an online discussion forum. Activities which include modelling, explanation, coaching, scaffolding, reflection, articulation, and exploration were utilized to meet the training objectives. Instructors were facilitators, coaches, and scaffolders for both learning content and process, with students as active participants. When students enter the online learning environment, they first gain experience through observing the processes demonstrated by the lecturers. For instance, a lecturer demonstrates open communication to model social presence. Then, he/she explains the importance of setting a positive environment through social presence. Next, the students shift from observation to active practicing by completing a small, simple task while receiving feedback from the facilitators. As students become more experienced in applying different types of practice, facilitators start fading (reducing the intervention).

Instrumentation

Garrison and Akyol (2013) proposed a list of metacognitive questionnaire items reflecting the roles of learners in a learning process as individuals and as members of a group. The questionnaire was translated into Bahasa Indonesia and adopted as an instrument of this study. The coding of the discussion transcript was guided by a coding protocol proposed by Shea et al. (2010) that has been translated and adapted to fit the context. The instrumentation of the study is presented in Table 2.

Data Collection and Preparation

Data were collected from questionnaires, in-depth student survey feedback, and midterm and final test scores. The Likert's scale options for the e-learning competency questionnaire are (1) Poorly prepared, (2) Prepared, and (3) Well prepared. The six-level Likert's scales for the metacognitive questionnaires are: (1) Very untrue, (2) Untrue, (3) Slightly untrue, (4) Slightly true, (5) True, and (6) Very true. The ordinal data were prepared by utilizing WINSTEP based on the Rasch Model. Firstly, the data were transformed into logit (interval scale). Before further analysis, the transformed data were prepared by the following procedures: fit analysis, the validity of rating scale, unidimensionality of the data, and normal distribution.

Fit Analysis

Fit statistics consists of inlier-sensitive (infit) mean square, outlier-sensitive (outfit) mean square, and standardized fit statistics. They indicate how data accurately or predictably fit the model (Linacre, 2002). The following table is the summary statistics of the metacognitive questionnaire data. In general, both the pretest and posttest data fit to the model. Both the infit mean square and the outfit mean square values fall between 0.5 and 1.5, therefore the data are productive for measurement. The z-standardized values are greater than -2 and less than 2, hence, the data have reasonable predictability (Linacre, 2002). In addition, both the respondents and the items are reliable in terms of internal reliability. See Table 3.

Rating Scale Validity

All the options were chosen by respondents. The rating scales are valid as shown by the observed average values and the Andrich Threshold values that are in ascending order.

Unidimensional Data

The raw variance of the data is 25%; it is greater than the minimal accepted value of 20%. The greater the raw variance, the better. The unexplained variances are, consecutively, 10.1%, 8.6%, 6.7%, 5.8%, and 5.5%, which are lower than the maximum accepted value of 15%. Therefore, the questionnaire data are unidimensional.

Normal Distribution

The p-values of the One-Sample Kolmogorov-Smirnov test for distribution are presented in Table 4.

Table 3. Metacognitive Questionnaire

Criteria	Statistics (Pretest)	Statistics (Posttest)	Accepted Range	Note
infit Mean Square	0.98	0.98	0.5–1.5	ideal:1.00
infit Z-Standard	-0.3	-0.2	-2–2	ideal: 0.0
outfit Mean Square	1.00	0.98	0.5–1.5	ideal:1.00
outfit Z-Standard	-0.1	-0.2	-2–2	ideal: 0.0
Item reliability	0.91	0.90	> 0.7	
Person reliability	0.77	0.87	> 0.7	
Cronbach's Alpha	0.86	0.89	> 0.7	

Table 4. The p-value for the Normal Distribution Test

	p-value (Pretest)	p-value (Posttest)
Class A	0.406	0.450
Class B	0.719	0.565

The p-values are greater than 0.05 for both the pretest and the posttest of each class. Therefore, the data follow a normal distribution. Using the same procedures, the data from the e-learning competency questionnaire were examined prior to the analysis. The data fit with the model, they are unidimensional, and they follow a normal distribution. The rating scale is valid, and respondents were not confused with the choices.

Questionnaire data of Class A and Class B students were compared to find changes caused by different learning experiences. To interpret the results of the study, the questionnaire data and in-depth survey data were analyzed separately and then compared. The findings of various data analyses that lead to a similar conclusion are integrated and interpreted. The conclusion will then be drawn based on the data from various sources that are consistent with one another. Findings which cannot be interpreted require further investigation.

Transcript analysis begins with identifying representative samples, determining the coding protocols, and encoding the transcripts. There were 500 student messages of online discussion forums (after the training) that were selected. In the two weeks of discussion, 103 students were grouped into 12 small group discussion forums while the lecturers did not provide instructions or directions regarding the discussion process. Therefore, the indicators appear naturally, without being asked or directed by the instructors.

The coding of the discussion transcript is guided by a coding protocol proposed by Shea et al. (2010) that has been translated and adapted. Junus et al. (2015) have piloted the use of the adapted protocol in previous studies. The unit of analysis was each message. Each message was coded for all three presences; each cognitive presence was further coded for subindicators of triggering event, exploration, integration, and resolution. Although a CoI component appears in various forms in a single message, it is only counted as one presence of this component. One message may contain more than one component.

Three coders worked independently and the Fleiss' Kappa coefficient of the social, teaching and teaching presences are 0.895 (almost perfect agreement), 0.747 (substantial agreement), and 0.588 (moderate agreement) respectively. The Fleiss' Kappa for other indicators is in Table 5.

Table 5. Interrater Reliability: Fleiss Kappa

Category	Percentage of Agreement	Fleiss' Kappa	Interpretation
Triggering Event	87	0.6922	Substantial Agreement
Exploration	67	0.4026	Moderate Agreement
Integration	65	0.5298	Moderate Agreement
Resolution	92	0.5505	Moderate Agreement

Transcript analysis was used to answer the first research question. Data analysis on the metacognitive questioners, test scores, and in-depth survey were conducted to address the second research question.

RESULTS

Research Question (1) How to design CoI training to improve students' critical thinking?

To address the first research questions, a training strategy was proposed, then the strategy was applied in the discussion of linear systems. Students were expected to apply their discussion skills to learn about vector spaces using online collaborative learning. The discussion transcripts were coded and analyzed to investigate their critical thinking levels based on components of cognitive presence.

The training was divided into two phases. The first phase focused on active learning and social and teaching presences, as suggested by Nieto and Sainz (2011). They suggested the need for greater emphasis on the disposition due to its positive influence on the effective application of the learning skills taught. The main activities applied were modelling and explanation.

The second phase, the main step of the training, focused on developing cognitive presence skills in problem solving. During the second phase, students were given problems to solve collaboratively and all cognitive apprenticeship activities were applied at this stage. It should be noted that although the course was conducted in a blended-learning environment, the training was implemented fully online.

At the beginning of the second phase, students were given a mathematical problem to solve in the online discussion board. The problem was how to solve effectively linear systems, having m equations involving n unknown. Cognitive apprenticeship was applied to train students about cognitive presence, consisting of the four phases of practical inquiry: triggering event, exploration, integration, and resolution. Practical inquiry began with a triggering event as indicated by a dilemma, followed by brainstorming or exploration in search of relevant information. A move to the integration phase was indicated by connecting ideas in search of a solution to the problem. Defending the solution or applying the solution in different contexts was the final stage of practical inquiry (Garrison et al., 1999). Table 6 presents the activities of the facilitator and students in an online discussion forum during this phase.

Table 6. Cognitive Apprenticeship Activities Applied on Cognitive Presence

Strategy	Facilitator Activities	Students Activities
	Triggering Event	
Modelling, Explanation, Exploration	• Demonstrate how to define problems with the linear system, ask students to identify and explore dilemmas • Explain the meaning of the triggering event and the importance of defining problems properly • Explain the indicators of the triggering event	• Attend, observe • Ask questions, request clarification
	Exploration	
Explanation, Coaching, Reflection, Articulation	• Explain the indicators of exploration • Encourage students to explore ideas relevant to solving linear systems and provide feedback if needed • Ask students to list methods of solving linear systems • Ask students to reflect on the exploration process and articulate their thoughts	• Attend • Brainstorming • Self-reflection • Share their thoughts
	Integration	
Modelling, Explanation, Coaching, Reflection, Articulation	• Model how to connect ideas in the search for a viable solution; for example, compare the complexities of two simpler methods • Ask students to evaluate the methods of solving linear systems • Provide examples of indicators of integration • Encourage students to apply integration skills and provide them with feedback • Identify constraints faced by students, offer individual or group assistance, and discuss students' excerpts to improve their understanding • Motivate students if needed • Ask students to explain their learning experience to enhance problem-solving skills	• Observe • Connecting ideas • Compare and contrast • Propose possible solutions
	Resolution	
Explanation, Coaching, Exploration, Reflection, Articulation	• Explain indicators of resolution and assist students by directing and providing advice or simple examples of resolutions • Monitor the discussions, provide feedback, and encourage students to apply their skills • Encourage students to apply the skills in a more ill-structured task; for instance, defend the solution or apply the solution in different contexts • Gradually stop the aid as students start showing their competency • Trigger students to assess their learning skills • Encourage students to articulate their learning experience	• Practice/apply new skills about cognitive presence • Construct resolution by defending their solution • Scaffold each other • Self-reflection • Express ideas, thoughts, understanding, impression, awareness, or activities

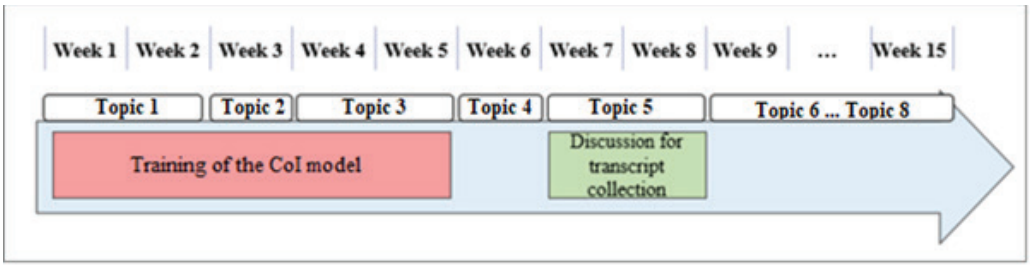

Figure 2. The CoI Training Schedule

The learning and training objectives are explicitly explained at the beginning of the course. The students are informed about the rationale and the benefits of each training activity. They are encouraged to take an active role, not to be afraid to make mistakes, and to convey any encountered obstacles. The whole learning process requires high commitment and the students' engagement, and therefore, the students must be aware of the importance of collaborative learning.

The training was conducted in an integrated manner through the following lessons: Topic 1 (Linear Systems), Topic 2 (Matrix Algebra), and Topic 3 (Determinant). It must be noted that students have been introduced to these three topics during high school. To ensure that the students attain the objective of the training and the course, the training was implemented at the beginning of the course with the topics with which the students are already familiar. The integration between subject matter and training are shown below.

Skills developed during training were applied throughout the course. For the purposes of this study, the online discussion transcript was drawn on the discussion of Topic 5 (General Vector Spaces), which is a topic that requires the accommodation process. The discussion was done entirely online. Lecturers presented regularly but limited their intervention in the discussion process, so that what appeared in the online discussion occurred naturally without being directed either directly or indirectly by the lecturers. The presence of lecturers remained important to make the students not feel left out.

In the discussion of Topic 5, the students were grouped into focus groups consisting of five to seven students with each group being given an ill-structured problem. Students were then expected to apply the discussion skills they developed during the training to solve given problems. Students were required to produce a discussion report as a conclusion. The purpose of this strategy was to encourage students to become more positively interdependent towards one another in applying their collaborative online learning skills.

Transcript Data Analysis

The content analysis explored the indicators of critical thinking levels. Cognitive presence, the core of critical thinking, arises as much as 42%. The 210 messages containing cognitive presences (out of 500 messages) specified the emergence of the indicators of critical thinking levels: triggering events, exploration, integration (integration of ideas from various sources, linking some concepts, proposing a solution), and resolution (applying solutions in other contexts or defending solutions). Mostly, the resolution appeared in the forms of axiom proving (see Figure 3).

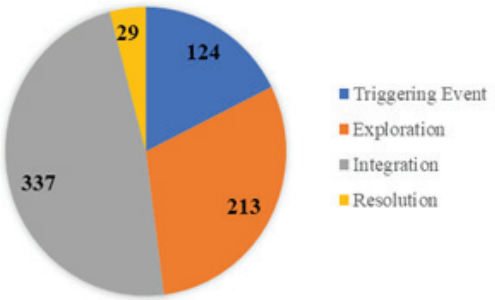

Figure 3. Critical Thinking Level Frequencies

Triggering event appears most intensive at the beginning of the discussion when students attempted to define the problem, followed by brainstorming and exploring ideas. In general, the most dominant indicator was the integration that comes in the forms of responding to other student ideas and connecting concepts. When expressing agreement or disapproval, students tended to give

Table 7. Paired Sample Test for the Equality of the Means of Pre-and Posttest (Class A)

	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
Pair 1 Pretest Measure Posttest Measure	.285	.67016	.084	-.454	-.117	-.3.38	62	.001

reasons. The resolution was observed least in the cognitive presences.

Research Question (2) What is the impact of the training on students' self-regulation and coregulation?

To address Research Questions (2), data were collected from three sources: metacognitive questionnaires, in-depth surveys, and midterm and final test scores. The results are discussed in detail in the following.

Metacognitive Questionnaire

Comparing respondents' responses on the pretest and posttest, paired t-test, the mean measures of Class B students are not significantly different with a p-value of 0.076. On the other hand, the mean scores of the Class A students increase significantly with a p-value of 0.001.

The Rasch Model provides comparisons of responses the pre- and post- at the item level to identify items that exhibit DIF (Differential Item Functioning) as the function of pretest and posttest. From the measurement perspectives, the items measure traits in different ways between the pretest and the posttest to see if the pretest is higher than the posttest or vice versa. The list of items and their measures on the pretest and posttest, together with the probability values, is presented in Table 8. The smaller the p-value, the greater the response difference between the pretest and the posttest.

The p-value of an item equal to 1 means there is no difference in students' responses to the item between the pretest and the posttest; for instance, items I11 "I am aware of my effort" and K12 "I help the learning of others." Items having p-values close to 1 are responded in somewhat the same between the pretest and the posttest. An item having probability (p) value less than 0.05 means the item measures a different trait for the pretest and posttest (Boone, Staver, & Yale, 2014). The items having p-values less than 0.05 are I6 "I am aware of my existing knowledge" and I9 "I change my strategy when I need to." Changes happened in Class A alone; therefore, it was likely caused by the training. If a DIF is exhibited simultaneously in both Class A and Class B, then it is unlikely due to the intervention.

In-depth Survey

An in-depth survey was conducted via email to all Class A students in early December 2016 (the end of the third semester). There were sixteen students responding to the open questions of the survey. From the responses, we constructed several themes below:

1. *Technical obstacles or challenges*—The Internet connection in the campus is very good; however, around 50% of the students have limited Internet access at home during a certain period of times. Therefore, they rely on facilities provided by the campus.

2. *New learning experience obtained in online learning*—Online discussion makes students learn a new mechanism to share ideas in learning. They negotiate to construct meanings facilitated by an online discussion forum. Students claim that communication skills and ability to review materials have increased.

3. *Applicability of collaborative online learning skills gathered*—In general, the use of an online discussion forum in other courses is not as optimal as in the Linear Algebra course. Therefore, they do not apply collaborative online learning skills they have learned.

4. *Challenges faced by the students*—Students are concerned that their responses (contents or selection of a sentence) are not satisfactory, the difficulty in managing learning motivation and academic load discipline, and the difficulty in understanding the opinions of others and in

Table 8. Item Measures and Probability Values of Items

		Class A			Class B
Code	**Metacognitive Questionnaire Item**	**Pre test**	**Post test**	**p**	**p**
When I am engaged in the learning process as an INDIVIDUAL					
I1	I am aware of my effort	-.24	-.22	1.00	.8703
I2	I am aware of my thinking	-.39	-.14	.3326	.6672
I3	I know my level of motivation	-.04	-.36	.1583	.5400
I4	I question my thought	-.39	-.09	.0689	.1259
I5	I make judgments about the difficulty of the problem	-.04	-.19	.8047	.6305
I6	I am aware of my existing knowledge	-.54	-.57	.0195	.8198
I7	I assess my understanding	-.15	.68	.7618	1.000
I8	I am aware of my level of learning	.62	-.16	.6865	.2966
I9	I change my strategy when I need to	-.01	.76	.0022	.7461
I10	I search for new strategies when needed	.02	.28	.2764	1.000
I11	I apply strategies	.63	.41	.2994	.5678
I12	I assess how I approach the problem	-.21	-.01	.4231	.9459
I13	I assess my strategies	.46	.59	.572	.7140
When I am engaged in the learning process as a member of a GROUP					
K1	I pay attention to the ideas of others	-.61	-.9	.2703	.4861
K2	I listen to the comments of others	-.71	-.83	.6475	.5623
K3	I consider the feedback of other	-.85	-.93	.7582	.3420
K4	I reflect upon the comments of others	-.54	-.71	.5053	.1756
K5	I observe the strategies of others	.78	.6	.4075	1.000
K6	I observe how others are doing	.21	.28	.7844	.5330
K7	I look for confirmation of my understanding of others	.1	-.06	.4458	.3176
K8	I request information of others	-.39	-.45	.7697	.1211
K9	I respond to the contributions of others	.13	-.09	.3228	.6678
K10	I challenge the strategies of others	1.02	.86	.4929	.0567
K11	I challenge the perspectives of others	-.21	.01	.398	.4559
K12	I help the learning of others	.7	.72	1	.1754
K13	I monitor the learning of others	.41	.52	.6335	.1339

expressing one's own thoughts.

5. *Benefits of using an online discussion forum*—Students reveal that the learning experience in Linear Algebra helps them to learn in three aspects: improving their understanding, providing a stimulus for reflection and motivation to learn, and enhancing their learning strategies. Online collaborative learning facilitates information sharing, confirms understanding, and evaluates and diagnoses misconception. Students are exposed to a variety of ideas, viewpoints, and learning strategies. Getting involved in an online discussion forum can expand and enrich their problem-solving strategies. The online discussion forum maintains connectivity between students and lecturers not only seen in face-to-face classes.

6. *The variation of students' participation in an online discussion forum*—The levels of students' participation is not equal; some students are very active, but a small portion of students become passive participants. They suggest more intervention by lecturers to keep the discussion going. It indicates the dependence on facilitators' intervention.

Student opinions in the in-depth survey are also revealed in online discussion transcripts

Table 9. Themes and Example of Statements

No	Themes	Example of Statements
1	Technical obstacles or challenges	"The Internet connection on campus is good, but it is worse at my home. This makes it difficult for me to attend the online discussions when I am at home. "
2	New learning experience obtained in online learning	"In the Linear Algebra Class, for the first time learned how to criticize the opinions of others. In addition, I learned how to express opinions and ethics in online discussions." "The new thing I learned about this online learning is that some interesting questions that cannot be delivered in (face-to-face) class can be discussed in the discussion forum."
3	Applicability of collaborative online learning skills gathered	"So far I have not gotten a class that implements consistently online discussions like the Linear Algebra class." "Until now, online learning is applied outside the Linear Algebra class but not as intensive as applied to the Linear Algebra class." "Other classes do not implement discussion forum for teaching and learning activities, but are used for posting assignments, notification, or announcements."
4	Challenges faced by the students	"In a group discussion sometimes the answers posted by members were not synchronized." "Time, because time management is not good, so it's still a bit difficult to set the time for discussion." "Discussion with others who are not so well familiar." "Afraid to answer wrongly so it will be embarrassing in front of other people." "I'm worried if my answer is wrong and not being corrected, another group member might think it is true." "I found sometimes some of my friends wrote without searching for information first, I think this is very problematic especially if no other friends who straighten." "distraction of other websites on the Internet"
5	Benefits of using an online discussion forum	"I learned how to write ideas in a discussion board systematically in order to be understood by others. In addition, I also learned that there are many different complementary opinions from peers. I also learned how to criticize others' opinions not just accepting them." "Online discussion is certainly very helpful because it is flexible, and I can ask about the material that I could not say in class, anytime."
6	The variation of students' participation in an online discussion forum	"In my opinion, I and some of my friends have contributed enough in the online discussion, but because of some constraints, some students were confused and might decide not to respond and therefore their contribution was less noticeable."

The in-depth survey shows that online discussion forum is both challenging and beneficial for students.

Midterm and Final Test Scores

Class A and Class B were given the same questions on the midterm and final exams. The types of questions included multiple choice, a long essay, and True/False with argumentation (T/F). For the T/F with argumentation questions, scores were given based on the quality of the argument; that is, the more logical and coherent the argument, the higher the score. The average total scores of Class A and Class B students do not differ significantly. However, at the midterm test, the mean score of Class A students was significantly higher in answering questions that require arguments. The sentences they presented were longer and intact (containing subjects, predicates, and objects).

DISCUSSION

This study confirms that uncertainty is a constraint that appears in online learning that can reduce the motivation to learn, as described by Palloff and Pratt (2005). Students are concerned about the truth of their own understanding and

contributions of others. They require confirmation from the lecturer as a subject expert. Because collaborative online learning is a new experience, students need time to adapt to the role of learning partners and learning resources for other learners. Some students have difficulty conveying ideas in writing. The in-depth survey also reveals that students expect more instructors' facilitation. It is consistent with the lower indicators of teaching presences.

There are changes in students' perceptions of the ability of metacognition. To interpret the results of the study, the findings have been compared. The findings of the quantitative data analysis that is consistent with qualitative data are the following:

- The metacognition means scores of Class A increase significantly.
- Class A students attained higher marks in answering argumentative questions.
- Class A students reached each of the critical thinking levels; integration/synthesis indicators appear most dominant.
- Some Class A students claim that their communication and learning skills have improved.

In addition to improved metacognitive strategies, students admit the training enhances communication skills. Unfortunately, during the next semester, students do not get a learning environment that forces them to apply and cultivate learning skills developed during the training. Learning and critical thinking skills are enhanced if they are applied in different contexts. Therefore, cultivating learning and critical thinking skills should be planned at the institutional level. It begins by setting the capacity of lecturers to play their active roles. An active learning paradigm needs to be well understood by teachers and education managers before implementing active learning methods. To implement collaborative learning online, educational institutions need to help faculty members develop their capability in planning, executing, and evaluating the learning process.

The least amount of practical inquiry activity was resolution, while both exploration and integration were high. The low frequency of resolution is understandable considering that defending a solution or the application of a solution in different contexts requires higher-order thinking. The integration mostly appeared in the online messages. It indicates students' ability to write syntheses and to infer relationships among ideas. The intensity of the indicators shows positive dependency among learners.

Comparing respondents (Class A) pretest and posttest, two items (I6 and I9) exhibit DIF. This means that the items measure traits in a different way for the pretest and posttest. The posttest scores of item I9 (I change my strategies if needed) is higher. On the contrary, the responses to the item I6 (I am aware of my existing knowledge) decreased. Further investigation is needed to understand this phenomenon.

Changing learning strategies requires metacognitive self-regulation and coregulation. The online discussion forum exposed students to others' learning strategies. If their strategy was not sufficient to accomplish tasks, they used another new strategy that was more appropriate. This new strategy was obtained by observing others, and the strategy was involved in the completion of tasks in an online discussion forum.

LIMITATIONS

Limitations of this study are that the interventions were not tested in other courses or in different contexts to obtain comparative information. In addition, the study did not include the discussion transcripts that reflect the discussion process. The learning environment of the following semester does not encourage students to apply the skills acquired during the training so that the impact of the intervention cannot be measured.

CONCLUSION

Online collaborative learning is a new experience for students and they need training to help them take an active part. This study confirms that efforts should be made to improve the readiness of students in collaborative online learning. Students exhibit intensive integration level (level 3). Training in the CoI model is the first step towards helping students fulfill their role in collaborative learning with an online discussion forum. Online learning accompanied by the training experiences have been perceived useful for students to improve communication skills and understanding. In addition, the learning experiences increased their metacognitive ability. The online environment exposed them to various ideas and learning strategies and stimulated reflection and, therefore, they attained a high level

of cognitive presence. Moreover, students' ability to present argumentation also improved, even though there is still not enough evidence of improvement when looking in terms of total test scores. Further efforts need to be done to help the beginner students improve learning independence and self-discipline, which are required in an online learning environment. It requires the active engagement of students and instructors' preparedness.

Training in the CoI model using a cognitive apprenticeship approach can then be integrated into a course provided that the course subjects, as the training domain, are carefully selected. The lesson plan should also be thoroughly designed so that both the learning and training objectives are achieved. Training in the CoI model is designed to support the attainment of the learning objectives.

Learning skills acquired in the training should be fostered by applying the skills in another context, otherwise, they will vanish gradually. Therefore, development of learning skills should be part of the institution's strategic plan.

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