Social, Cognitive, Teaching, and Metacognitive Presence in General and Focus Group Discussion: Case Study in Blended e-Learning Linear Algebra Class

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***Abstract*— Online discussion forum in mathematics teaching still needs to be investigated in order that educators can facilitate effective students online learning experience. The challenges faced in teaching Linear Algebra at the Faculty of Computer Science, Universitas Indonesia are that students are freshmen who are used to being dependent learners; and there is a time restriction to face-to-face interaction, while this course requires high interaction between students and instructor. To enhance communication beyond the classroom, we have implemented a blended-mode in the teaching-learning process (face-to-face and online learning). For the purpose of the study, two types of discussion were utilized: general (class) discussion and focus-group discussion forums. This study used message as the unit of analysis. We found that students tend to exhibit teaching presence more intense in small focus-group discussion than in general forum. It is also interesting to note that the students regulated their cognition more in focus-group forum than in the general one.**

Keywords*— *community of inquiry*; *online group discussion*; *collaborative learning*; *mathematics education

I. Introduction

Linear Algebra is a compulsory course for Computer Science and Engineering students. It prepares students with tools for problem solving related to matrix and vector algebra and mathematical thinking, especially in finding pattern and abstraction. Teaching to think mathematically can be achieved by applying the skills; therefore, it should be conducted in active learning approach.

The challenge faced in teaching Linear Algebra at our Faculty is that the students taking this course are first year students who are going through an adaptation period from high school to university learning environment, from being individual and dependent learners to a collaborative and more self-regulated learner. The other obstacle is that the learning objective to prepare students to think mathematically has not been fully understood as reflected in the course evaluation. These fresh high-school graduates usually expect more calculations-oriented learning activities and less conceptual problem solving which might be caused by testing systems to enroll in reputable universities. They learned mathematics in such a way to prepare themselves to pass university entrance tests which are usually available in multiple-choice problems.

Considering the amount of topics to be covered in Linear Algebra class, a 3-hour face-to-face session a week is definitely not adequate. This course requires high interaction between students and instructor. To enhance communication beyond the classroom, lecturers have implemented a blended-mode using Student Centered E-Learning Environment (SCELE – http://scele.cs.ui.ac.id/), a Moodle-based learning management system customized by our Faculty [1].

Teaching Linear Algebra, partly pure science, in the CoI framework is a challenge. The learning experience which should be focused on constructing knowledge collaboratively should be conducted in a student-centered approach. The other challenge is to maintain students' motivation to learn. Lazlo showed that the most dominant factors that influence learning motives are relevance, self-efficacy, instructors' support, and students' emotion during learning [2].

Since mathematics is a social activity that takes place in a community of learners or practitioners [3], asynchronous online discussion plays an important role in facilitating student-student and student-instructor interactions beyond the classroom. For the purpose of the study, two types of discussion are utilized: general discussion and focus group discussion forum. General discussion forum is an online discussion forum where all students taking the course can participate. The focus of this study is to investigate the patterns of social, cognitive, teaching, and metacognitive presences in online general discussion forum and those in focus group discussion. The findings will be used for future research topics.

II. Literature Review

A. Community of Inquiry: A Model of Online Learning

According to Garrison and his colleagues, the CoI is a process model that regards online educational experience as the dynamic of three presences: social, cognitive, and teaching presences [4]. Originally, social presence was defined as the ability of learners to reflect themselves as 'real' person [5]. Garrison in [6] extended the definition of social presence as

"the ability of the participants to identify with the community (course or study), communicate purposefully in a trusted environment, and develop inter-personal relationship by way of projecting their individual personalities." The definition reflects the purpose of social presence to establish a 'safe' learning environment.

Cognitive presence within the CoI framework is defined as the extent to which learners construct meaning through critical reflection and discourse [4]. Cognitive presence is operated through group-based practical inquiry process focusing on four phases: triggering event, exploration, integration, and resolution. Since it was argued that cognitive presence is the heart of educational experience in constructing knowledge through reflection and collaboration (discourse) in the community of inquiry, cognitive presence is closely related to critical thinking [4].

Teaching presence, which is reflected by the structures and leadership to sustain the community of inquiry, is described as a binding element of the development of both social and cognitive presences. Each of the presences is composed of categories the indicators of which are useful to find the indication of the presences in the discussion transcript. Garrison provided the coding template as appeared in Table I [4].

Garrison argued that social presence is necessary but not sufficient to ensure critical discourse [7]. On the other hand, social presence is maintained through interactions of cognitive and teaching presence [8], which correlates positively to cognitive and social presence [9].

The CoI model assumes that online learning, especially higher-order learning, is reflective and collaborative; it is both individual and social processes [10]. Knowledge is constructed individually (reflection) with the benefits of the ideas of others [4]; therefore, to facilitate online learning, content should not be taught as sets of facts and propositions. Content should be presented in such a way that encourages students to develop critical discourse.

B. Metacognitive Skills for Online Learning

Metacognition is an essential cognitive ability to achieve deep and meaningful learning [11]. The three-dimension of metacognition includes knowledge of cognition (KC), monitoring of cognition (MC), and regulation of cognition (RC) [5]. Magno argued that metacognition skill influences critical thinking [12]. Moreover, metacognition is an intersection of cognitive presence and teaching presence and is facilitated by social presence [11]. Akyol [13] proposed the metacognitive construct that can be used to indicate metacognition presence in asynchronous discussion forum (Table II).

TABLE I. THE COMMUNITY OF INQUIRY CODING TEMPLATE

Elements	**Categories**	**Indicators** (example only)
Social presence	• affective expression • open communication • group cohesion	• emoticons • risk-free expression • encouraged collaboration
Cognitive presence	• triggering event • exploration • integration • resolution	• sense of puzzlement information exchange • connecting ideas • application of new ideas
Teaching presence	• design and organization • facilitating discourse • direct instruction	• setting curriculum and methods • sharing personal meaning • focusing discussion

TABLE II. THE COMMUNITY OF INQUIRY CODING TEMPLATE [13]

Metacognition in a Community of Inquiry		
Knowledge of Cognition (KC) (entering knowledge/ motivation)	**Monitoring of Cognition (MC)** (assessment/ task knowledge)	**Regulation of Cognition (RC)** (planning/ strategies)
Pre-task reflection • Knowledge of the inquiry process • Knowledge of critical thinking and problem solving • Knowledge of factors that influence inquiry and thinking • Knowledge of self as a learner • Knowledge of discipline • Knowledge of previous experience • Expectancy for success	*Reflection on Action* • Declarative; judging • Commenting on task, problem or discussion thread • Asking question for confirmation of understanding • Commenting about self's and others' understanding • Making judgements about validity of content • Commenting on or making judgements about strategy applied • Asking questions about progression or stalling • Assessing motivational state and effort required	*Reflection in Action* • Procedural; planning • Setting goals • Applying strategies o Providing/ asking for support o Challenging self or others o Asking question to deepen thinking o Asking for clarification o Requesting information o Self questioning • Questioning progression, success • Taking control of motivation and effort • Facilitating/ directing inquiry

III. DATA COLLECTION AND ANALYSIS

A. Participants

The study was limited to participants (the instructors and students) in two Linear Algebra classes attended by a total of 97 students. The students were not informed about the elements of the CoI framework, nor metacognition. In the first semester they were trained to use leaning skills especially learning by using collaborative learning or problem-based learning approaches.

IV. PRACTICAL IMPLEMENTATION

During the discussion, the instructor regularly encouraged students to actively participate in the discussion by showing them the benefits of collaborative learning and learning from each other. This phase was considered important because, in the previous levels of education, the students used to learn

individually in teacher-centered approach and where peers were considered as rivals, not as partners in learning.

A. Class and Context of the Activity

The course covered eight topics which were delivered in blended mode. The face-to-face sessions focused on learning experiences which were difficult to be conducted online, such as theorem proving, developing procedures, models of problem solving, finding patterns, and home group discussion. The online learning activities were conducted to enable students to upload learning materials, writing glossary, or, for the instructors, to publish announcements, and discussion forum, which consisted of two types: general (class) and focus group discussions. Although most general discussions were initiated by the instructor, some were initiated by students when they asked for clarification, sought for more information, or shared values. Each of the topics of the course had a discussion forum.

The general discussion forum was intended to prepare students for the upcoming lesson, to help students learn more deeply (internalization) by learning collaboratively, and to do self-assessment and to provide feedback. To keep the online learning activities coherent with the face-to-face session, the instructor designed a program mapping. In addition, the triggers of the discussions were prepared before the class began.

Topic 5, i.e., General Vector Spaces was conducted in collaborative learning (CL) jigsaw model. The focus group discussions were conducted online, and then the home group discussion was done in class session, followed by internalization (lecturing) process.

Before entering the CL, students were prepared with properties of Euclidean vector spaces in terms of addition and scalar multiplication. Next, students were divided into focus groups consisting of four to five students. In the focus group discussion each group was assigned a task to investigate if ten axioms of vector spaces hold for a given system $(V, +, .)$, a non-empty set V provided with addition and scalar multiplication. They were expected to compare the patterns with the properties of Euclidean vector spaces. The systems $(V, +, .)$ are as follows.

- $(M^{2x3}, +, .)$ the set of all 2x3 matrices with real entries,
- $(P^3, +, .)$ the set of all polynomials with degree at most three system $(V, +, .)$,
- $(C_{[0, 1]}, +, .)$ set of all continuous functions at the interval [0, 1],
- $(D_{[0, 1]}, +, .)$ set of all differential functions at the interval [0, 1], and
- $(S, +, .)$ set of all infinite sequences with real terms.

Each group selected a group leader. The instructor's interference was kept to minimum. The focus group discussion was followed by a general forum. In the general forum, students discussed their findings of their focus group discussion. From the sharing and pulling process, they were expected to find the pattern and were ready to define general vector spaces.

B. Procedure

This study used message as the unit of analysis for several reasons. Message unit is identifiable, the number of messages is manageable, and the parameters of the unit are determined by the poster, not by the coder [15]. Paragraph unit was not suitable in this study because students presented their arguments using mathematical sentences, including mathematical elements and equations that did not form a regular paragraph. Sentence unit was not suitable either due to the variety of mathematical structures. For instance, to define general vector spaces one requires to consider ten axioms, each presented in one sentence. On the other hand, there are only two axioms to define a linear transformation.

Data collection started by compiling the entire transcript (text) into a file, followed by identifying and categorizing the target variables. As mentioned by Rourke, categorization of units of transcripts might not be free from the influence of the coders [15]; therefore, a coding protocol is utilized to avoid or minimize the subjectivity. The categories, the definitions of which are based on coding template developed by Garrison et al. [5], and metacognitive construct proposed by Akyol et al. [13] are used to identify presences.

During the coding process, each of the coder independently read through the transcript using the coding scheme. The presence codes were applied to each message posted by student participants, for which the coders investigate the cognitive presence (CP), social presence (SP), and teaching presence (TP). Certain words/ phrases might indicate certain elements. If there was no evidence of a presence then the message was coded zero. Next, final coding decision was made in consensus of two coders. Therefore, the interpreter reliability was not measured. Finally, the coders conducted frequency counts.

The limitation of the study was that the data collection relied on the interpretation of the messages by the coders. Some messages were difficult to categorize because there was no keyword. The coder had to look at the context of the discussion.

V. Practical Implementation

Some messages contained phrases that indicated certain contents that were easily observable; however, not all content could be found easily on the transcripts. Therefore, the coders had to look at the context of each trigger and its corresponding topic.

Table III presents the phrases that most commonly appeared in the transcript. In the first week there was no 'thank you' message from students. The instructor always concluded and started a conversation by thanking certain or all students for their specific contribution. However, beginning from the second week students almost always showed their gratitude to the others that indicate social presence.

TABLE III. PARTS OF SENTENCES INDICATING THE PRESENCES

Cognitive presence	Social presence	Teaching presence (peer)
Triggering events • I have difficulty in… • I think, the problem is… • I am confused about … • Is it true that the problem is about...? • Does this property hold for…. **Exploration** • If we relate … • If we investigate case by case… • Let's read the definition carefully. **Integration** • After I read all your postings, I conclude that… • Now I know that vector is … • I understand, now, that….. • I summarize … **Resolution** -	**Emotional expressions** • I am glad, I learnt a lot from all of you. • Thank you… • I have different opinion …. • I want to learn more. **Open communication** • Let's focus on …. • Thank you for your suggestion on …. • Please feel free to make any correction. • Please don't be afraid to make mistakes. **Group cohesion** • The success of this class depends on our contribution. • Learning collaboratively (collaborative learning) is beneficial, so…. • Can you provide examples? • Please tell us what you think about … • We'd better divide and distribute the task ….	**Instructional management** • We have problem to be solved… • Let's share our opinion about … • Our topic is ….. • We have to seek more information about … **Building understanding** • I think that … • We learn how to solve the problem. • I will summarize our discussion…. **Direct instruction** • I think …, I don't agree with …. Could you verify … • I will explain about … • Compare it with ….. • Look deeply about …..

Surprisingly, 35.07% of the students' messages contained students' request for correction or feedback, for instance "Please correct me if I am wrong"; "I need feedback"; "Please provide me better suggestion"; "I am not sure, I need your correction". These statements might not be an indication that they are not sure with their opinion, instead of seeking attention, being polite. In some Indonesian cultures, asking opinion is considered to be polite.

The total number of messages in the class discussion forum was 185. A message could contain one or more elements: social, cognitive, and teaching presences. Similarly, a message could indicate one or a combination of knowledge of cognition (KC), monitoring of cognition (MC), and regulation of cognition (RC). Table IV shows the percentage of the elements compared to the total number of messages. One message may contain one or more presences. The percentages of the social, teaching, and cognitive presences in the focus group discussion as shown in Table V. Note that the percentage is based on the total number of messages. A message may contain more than one presence.

TABLE IV. FREQUENCY AND PERCENTAGES OF PRESENCES IN THE CLASS DISCUSSION FORUM

Social Presence (SP)	Teaching Presence (TP)	Cognitive Presence (CP)
128	16	112
69.19%	8.65%	60.54%

TABLE V. FREQUENCY AND PERCENTAGES OF PRESENCES IN THE FOCUS GROUP DISCUSSION FORUM

Social Presence (SP)	Teaching Presence (TP)	Cognitive Presence (CP)
84	52	64
73.68%	41.18%	56.25%

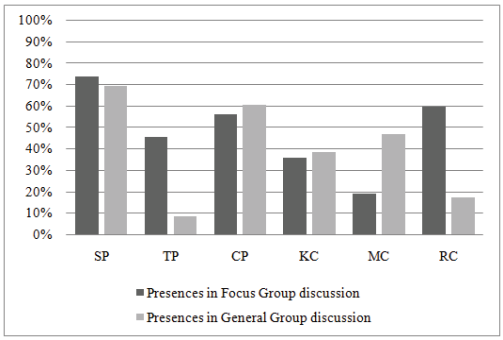

Fig. 1. Number of presences in focus group and general group

Students played their roles as facilitators when they were given more responsibility on their own group and the instructor restricted herself from interfering the discussion. The instructor still had to monitor and enter into the group, but she interfered in the discussion if necessary. Therefore, lecturer could help students on how to facilitate group discussion, to give constructive feedback, and monitor their learning. This should be done by being the role model and by giving direct instruction.

The difference between the number of social presence in the general discussion and that in the focus group discussion was small (Fig. 1). Similarly, the number of cognitive presence in the general discussion was quite the same as the number of cognitive presence in the focus group discussion. On the other hand, it seems that teaching presence in focus group discussion was higher than that in class discussion. The possible explanation is the following. In the group discussion, each group, led by a group leader whose primary responsibility was a facilitator, was assigned a task with a target to be accomplished and reported to other group. When students knew their target and roles, they become more responsible and facilitated each other to attain the objectives.

In terms of language utilization, students were using the language (Bahasa Indonesia) properly in the forum. Students are imitator in terms of communication language uses by the instructor; therefore, they adopt the style of the language in the

TABLE VI. METACOGNITION IN A COMMUNITY OF INQUIRY: EXAMPLES OF STATEMENTS

Metacognition in a Community of Inquiry: examples of statements		
Knowledge of Cognition (KC) (entering knowledge/ motivation)	**Monitoring of Cognition (MC)** (assessment/task knowledge)	**Regulation of Cognition (RC)** (planning/ strategies)
Pre-task reflection • Based on a paper I read …. • I think the the concept is not trivial. • I know better after reading your comment. • I am comfortable with the terms 'vectors of 4-dimension'. • Discussion helps me finding my own mistakes. • I can't wait to learn how to measure the length of a matrix. • I have to change my believe about vector. • Examples help me understand difficult concept. • The number topics we have to learn is a lot. • My prediction about space with negative dimension has been changed. • I understand your explanation. • I am sorry, I think I misunderstood you • After doing the quizes I realize I only understood the surface. • The questions were beyond my expectation. Very difficult. • Now I know clearly what vector is, but I start wondering the application of the new concept. • My previous believe about vector needs to be revised.	*Reflection on Action* • I realized that… • Good answer… • Very interesting comment. • I have learned that… • I wonder how to proof the theorem. • I am curious about … • I want to know more about … • I like your comment about… • Have we reached any conclusion? • Sorry, my previous posting was not answering the question. • This discussion is interesting and motivating. • We forgot a very important concept we learned in Calculus I. • Very inspiring! • I want to remind all of you that we made the same mistakes about…. • Thanks, you helped me organized my thoughts. • I am confused about… • Thanks, for your correction. I know my own mistakes. • Wow I thought this course was a nightmare. • interesting • You helped me to think critically. • I worked hard seeking a new knowledge, not wanting to be spoon feed. • I am not sure how to apply the concept, but I know for sure that the learning process itself is important for my future work. • Now I learn how to learn.	*Reflection in Action* • I appreciate your comment and I completely agree with you. • Your comment is clear, let's move to the next binary operations. • Based on some references, I think … • Writing your opinion deepen your understanding. • Could you help us with simple examples to help us understand the concept? • Please help me if I am wrong. • Mam, please provide me with the old materials. I need to organize our knowledge. • I agree with you, I will add more information on that. • I have different opinion... • Can we have feedback on the quiz, we need to assess our own learning. • Please correct me, I am still not sure

TABLE VII. FREQUENCY AND PERCENTAGES OF ELEMENTS OF METACOGNITION IN THE GENERAL DISCUSSION FORUM

Knowledge of Cognition (KC)	Monitoring of Cognition (MC)	Regulation of Cognition (RC)
95	79	101
32.99%	27.43%	35.07%

TABLE VIII. FREQUENCY AND PERCENTAGES OF ELEMENTS OF METACOGNITION IN THE FOCUS GROUP DISCUSSION FORUM

Knowledge of Cognition(KC)	Monitoring of Cognition(MC)	Regulation of Cognition(RC)
41	22	68
35.96%	19.30%	59.65%

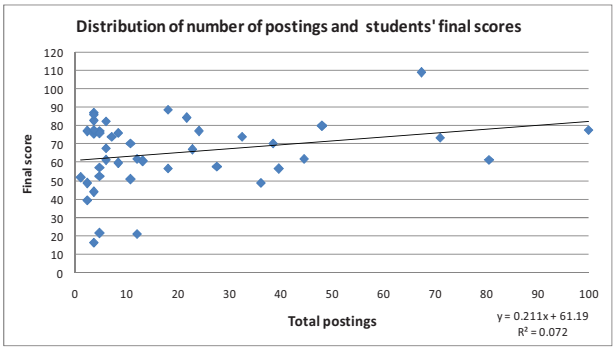

Fig. 2. Distribution of number of postings and students' final scores

discussion forum into their exam paper. While they are actually communicate outside the class using informal language with a lot of slang words.

Most of the discussion contents were questions about detailed information, clarification, adding new information, correction of others' or their own comments. Disagreement occurred on minor bases, and they reached agreement after a short period of discussion. It is quite intriguing to know that no lengthy debate happened. Table VII and table VIII present the percentages of the elements of metacognition in general and in focus group discussion.

The relationship between the number of postings and the final scores is presented in Fig. 2. The curve is close to linear with positive coefficient 0.2118. There were students who were not as active as others but they managed to get good marks (above 70). Interestingly, no active students failed in this course. It shows that active participants performed better compared to the less active students.

VI. CONCLUSION

The study is an early stage of understanding the dynamic of educational inquiry in the online learning environment. The result is descriptive. While general forum is a potential medium for internalization and finding misconceptions, focus group discussion is potential for improving students'

responsibility for their learning. Active (motivated) students performed better in the quizzes and examinations compared to the less active students.

The way students communicate socially is influenced by the language used by the instructor; this suggests that the instructor has the opportunity to help shaping the community. In their feedback, students expressed their appreciation when the content/topics are connected with moral values and with the application of the contents in other fields. Some students repeated the words of values in their posting. One student opened a discussion topic, especially to record the values or they wrote in their feedback at the end of semester. They need instructor to be their inspiration.

VII. Future works

Some topics for future work are how to better understand the portrait of students and how they develop the community of inquiry, to better understand the dynamic of metacognition in collaborative community of inquiry, what the relationship between social presence with co-regulation is, what the relationship between self-regulation with cognitive presence is, and what skills should be prepared for students to be better learners.

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