The Use of Self-Monitoring Tools for Linear Algebra Course in Student Centered e-Learning Environment

Kasiyah Junus[1]
kasiyah@cs.ui.ac.id

Harry B. Santoso[2]
harrybs@cs.ui.ac.id

Lia Sadita[3]
lia.sadita@cs.ui.ac.id

Faculty of Computer Science[1,2,3]
Universitas Indonesia
Depok, Indonesia

***Abstract*— The challenge faced in teaching Linear Algebra at the Faculty of Computer Science Universitas Indonesia is students are forced to accommodate their past understanding about vector with the new knowledge. Our past experiences show that self-monitoring and knowledge-sharing with other students are two effective strategies for enabling students' accommodation process. An approach proposed in the current study will apply intervention in a form of instructional method into Linear Algebra course facilitated with online collaborative and self-monitoring tools. Online collaborative tool used in the course is a discussion forum at a Moodle-based learning management system customized and maintained by the faculty. Self-regulated learning is used as framework and experimental research design is used to measure intervention effects on students' learning performance. The study will also use a metacognition questionnaire to analyze online forum discussion capturing students' self- and co-regulation. In addition to that, a correlation test will be conducted to investigate connections between self- and co-regulation with students' learning outcome. The preliminary findings show positive relationship with accommodation process.**

***Keywords*—collaborative; self-monitoring; linear algebra; student centered e-learning environment**

I. INTRODUCTION

There are some challenges in teaching Linear Algebra for first-year students at the Faculty of Computer Science, University of Indonesia. The students are going through a transition period from high school to university learning environment. From being individual and dependent learners to collaborative and more self-regulated. From learning process focused on solving routine problems into the process involved three aspects: contents, learning skills, and critical thinking. In addition, students are forced to accommodate their past understanding with the new knowledge (i.e., concepts of vector space).

Based on researcher's experiences in teaching Linear Algebra, two effective strategies for enabling students' accommodation process are self-monitoring and knowledge-sharing with other students. Those strategies are fit with the concepts of learning as a reflective and collaborative process. Knowledge is constructed individually (reflection) with the benefits of the ideas of others [1]. One important aspect of this process is students' ability to regulate their own learning; this is called self-regulated learning skill. Previous studies showed that self-regulated learning ability supports learning outcomes [2].

Self-monitoring activity related to concepts of general vector spaces in the previous classes of Linear Algebra was facilitated through writing in the paper-notes, then the reflection has summarized and showed to the students' at certain stages. This process is not effective both for instructor and learner because it is difficult to provide personalized feedback in a timely manner. Meanwhile, fast feedback response is useful for knowledge construction.

This course requires high interaction among students and between student and their instructor because of two-fold objectives: (1) to prepare students with tools for problem solving related to vector algebra; and (2) to enhance students' mathematical thinking. Due to limited time available for face-to-face interaction, the course is offered in blended mode of learning (face-to-face and online format). This course is using Student Centered E-Learning Environment (SCELE), a Moodle-based learning management system (LMS) customized and maintained by the Faculty [3]. The key focus of the student-centered learning is on the learners with the following characteristics:

- Learners are given responsibility to develop plans for their own learning [4].
- Learners are required to be active in the learning process, where the instructor only has a role as facilitator who guides the learning process happens [5].
- Social interaction in the discussion forum is essential to construct knowledge in the student-centered learning environment [5].

II. PURPOSE

The current study aims to provide teaching and learning practices of Linear Algebra course in an online learning environment through: (1) the creation of a learning environment that can enhance students' monitoring skills and revise their own understanding about concepts; (2) the creation of a learning environment that can enhance students' sensitivity upon their answers to questions; and (3) interactivity among students and between students and instructor by designing asynchronous discussion. A research question guided this study: *To what degree self-monitoring*

and collaborative learning process influence students' performance in Linear Algebra class?

III. Significance of the Study

The results of this study will yield a learning tool that can facilitate monitoring activities to revise students' past understanding about concepts. Moreover, assessment tool will be designed to help students think about their answers while solving problems. The current study will also provide a representative environment for interactivities among students and between students and instructor. This study will not only benefit the students, but also educators and curriculum developers. The researcher expected that the results would benefit researchers who are interested in developing a suite of tools for teaching Linear Algebra specifically in the Computer Science context.

IV. The Study

A. Participants and Context of Study

The participants for this study were 139 students enrolled in the Linear Algebra course during the spring 2014 semester. Linear Algebra is a compulsory course for Computer Science students. It prepares students with tools for problem solving related to matrix and vector algebra and mathematical thinking, especially finding pattern and abstraction. Experimental research design was used to measure intervention effects on students' learning performance. Fifty two students were assigned into treatment group and 87 students were assigned into control group.

B. Data Collection Procedures and Analysis

Self-monitoring prompts were used five times to encourage the students to think about the lesson. Journal module at SCELE is chosen as a self-monitoring tool (see Figure 1). Students were asked to answer questions that help them to monitor their own understanding on five different topics. Those topics are arranged to help students finding pattern and abstraction of general vector space concepts. Students were given three to five days to answer the directed questions in each self-monitoring phase. Since they had enough time to find the answer and think about their understanding, most of them justified their answer clearly.

Fig. 1. Self-Monitoring feature on SCELE

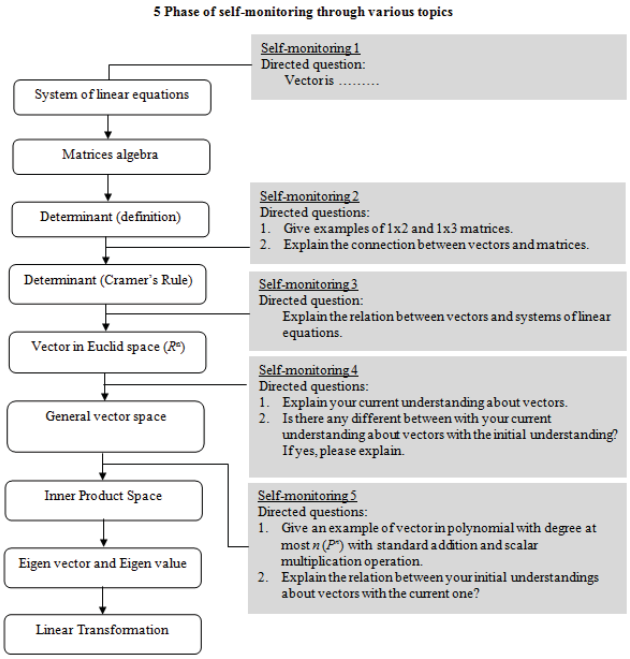

Fig. 2. The Five Phases of Self-Monitoring

The five phases of self-monitoring questions prompted students to check their understanding about vector, matrices, and systems of linear equations. Figure 2 shows how the questions were asked through the topics. For example, directed questions of self-monitoring 2 were given to the students after they learned about system of linear equations, matrices algebra and the definition of determinant. The questions include: (1) give examples of 1x2 and 1x3 matrices; and (2) explain the connection between vectors and matrices. Moreover, expected level of understanding for each self-monitoring stage can be viewed in Table 1.

TABLE I. Expected Level of Understanding

-th stage	Self-monitoring	Expected level of understanding
Stage 1	Self-monitoring 1	Students are able to define a vector as an entity having both magnitude and direction. It can be represented as directed line segment. They understand examples of physical vector such as force and velocity.
	Self-monitoring 2 and 3	Students are able to identify vectors in R^2 with matrices and system of linear equations.
Stage 2	Self-monitoring 4	Students understand Euclidean vector space R^n where $n = 2, 3, \ldots, n$; arithmetical operations and dot product.
Stage 3	Self-monitoring 5	Students are able to define vector as an element of vector space (matrices, polynomial, continuous function are example of vector).

In addition, metacognitive questionnaire developed by Akyol, Nordstokke, and Garrison [6] was used at the end of the semester. The students were asked to think about their Linear Algebra class while completing the questionnaire. The metacognitive questionnaire used in this study consisted of two categories, when a student is engaged in the learning process as (1) an individual, and (2) a member of a group.

TABLE II. EXAMPLES OF METACOGNITIVE QUESTIONNAIRE ITEMS

When I am engaged in the learning process as an INDIVIDUAL
I am aware of my effort
I am aware of my thinking
I know my level of motivation
…
When I am engaged in the learning process as a member of a GROUP
I pay attention to the ideas of others
I listen to the comments of others
I consider the feedback of others
…

TABLE III. SAMPLES OF STUDENTS' ANSWER AFTER SELF-MONITORING QUESTION #2

Categories	Number of respondents	Samples of students' answer
Representation	46	1. Vectors are matrices having one row or one column. 2. Vectors are nx1 or 1xn matrices where n = 2, 3. 3. Since vectors can be represented as matrices, matrices are expressible as directed line segments. 4. 3x1 or 2x1 matrices are vector in algebraic form. 5. Matrices consist of components (i.e. column) in forms of vectors. 6. Both vectors and matrices are data structures to store data. 7. System on linear equations can be simplified using vectors and matrices.
Arithmetic operation	12	1. Properties of algebraic operations of matrices and those of vectors are the same. 2. Vectors are the product of matrices multiplication. For instance $A_{3x2}B_{2x1} = C_{3x1}$. Vector C is the product of two matrices A and B.
Problem solving tools	6	1. Vectors and matrices play as tools for solving system of linear equations. 2. Vector and matrices can be used to simplify calculations to find solutions. 3. Operations on vectors and matrices are simple compared to manipulations on equations.

Students were asked to rate themselves on a 6-point Likert scale (1 = *very untrue of me*, 2 = *untrue of me*, 3 = *slightly untrue of me*, 4 = *slightly true of me*, 5 = *true of me*, 6 = *very true of me*). The internal consistency of the questionnaire is: .935 (see Table 2 for examples of the metacognitive questionnaire items).

V. PRELIMINARY FINDINGS

This section presents our preliminary findings regarding students' ability (n = 51) to accommodate their understanding about concepts of vector, matrices and system of linear equations. One respondent was left out for the analysis since the response shows there is misconception about the questions. These findings indicate that self-monitoring prompts successfully helped students in changing their understanding about the concepts taught in the course. For example, Table III and IV show how students' understanding changed after self monitoring #2 and #3. The number of students who stated that vector can be used as tool for solving problems was increased from 6 (12%) to 16 (31%) students.

A. Post Monitoring #1

After responding to self-monitoring question #1, all students were able to write down the definition of vector precisely as an entity that has length and direction.

TABLE IV. SAMPLES OF STUDENTS' ANSWER AFTER SELF-MONITORING QUESTION #3

Categories	Number of respondents	Samples of students' answer
Representation	30	Direct relation 1. A solution of system of linear equations is expressible as a vector $(x_1, x_2, x_3) = (1, 2, 0)$. Indirect relation 2. Vectors can be represented as matrices; matrices represent system of linear equation. 3. $ax + by + cz + k = 0$ as an equation of a plane having (a, b, c) as a normal vector.
Arithmetic operation	8	1. Properties of algebraic operations of matrices and those of vectors are the same. 2. Vectors are the product of matrices multiplication. For instance $A_{3x2}B_{2x1} = C_{3x1}$. Vector C is the product of two matrices A and B. 3. Operations of system of linear equations are applicable of vectors.
Problem solving tools	16	1. Problems related to vectors could be solved using system of linear equations. 2. Vectors are tools for solving system of linear equations.

B. Post Monitoring #2

Students' responses to self-monitoring question #2 can be grouped into three categories: representation (i.e., stated by 46 respondents), arithmetic operations (i.e., stated by 12 respondents), and problem solving tools (i.e., stated by 6 respondents). Each of student's response may belong to multiple categories.

C. Post Monitoring #3

Students' responses to self-monitoring question #3 can be grouped into three categories: representation (i.e., stated by 30 respondents), arithmetic operations (i.e., stated by 8 respondents), and problem solving tools (i.e., stated by 16 respondents).

D. Post Monitoring #4

After responding to self-monitoring question #4, four students said that their understanding was not changed; only one of them explained the reasons. However, the explanation indicated that there was a change in his understanding. Forty four students stated that their understanding was changed.

E. Post Monitoring #5

Almost all students stated that their understanding was changed after responding self-monitoring question #5, and they also defined a vector as an element of vector space.

VI. Future Works

The authors still have more work to be done for the current study. The efforts will focus on data analysis, specifically for data coding will be continued to describe 'meaningful' answers from the students. Initial effort on data coding provides confidence to conduct the process effectively. We will also analyze quizzes and exams results and conduct a correlation analysis to investigate connections between self- and co-regulation with students' learning outcome.

References

[1] Garrison, D. Randy, Terry Anderson and Walter Archer. 2001. *Critical thinking, cognitive presence, and computer conferencing in distance education*. American Journal of distance education 15, pp. 7-23.

[2] Pintrich, P. R., & de Groot, E. *Motivational and self-regulated learning components of classroom academic performance*.Journal of Education Psychology, 82(1), pp. 33-50, 1990.

[3] Hasibuan, Z. A.,& Santoso, H. B. (2005).*The use of e-Learning towards new learning paradigm: Case study student centered e-Learning environment at Faculty of Computer Science, University of Indonesia*. Prosiding the Fifth IEEE International Conference on Advanced Learning Technologies (ICALT '05), hal.1026-1030.

[4] Cannon, R. *Guide to support the implementation of the learning and teaching plan year 2000*, ACUE, The University of Adelaide, Australia, 2000.

[5] Motschnig-Pitrik, R.,& Holzinger, A. *Student-centered teaching meets new media: Concept and case study*. International Forum of Educational Technology & Society, 5(4), pp. 160-172, 2002.

[6] Garrison, D. R., & Akyol, Z. (2013). *Toward the development of a metacognition construct for the community of inquiry framework*. Internet and Higher Education, 17, pp. 84-89.