DEVELOPMENT OF LEARNING STRATEGY RECOMMENDATION SYSTEM TO TRAIN METACOGNITION AND SELF-REGULATED LEARNING IN ALGORITHM AND DATA STRUCTURE COURSE

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ABSTRACT

Metacognitive training system (MTS) which is developed for Algorithm and Data Structure course facilitates students to choose, use, and evaluate different learning strategies. Therefore, students are encouraged to be self-regulated. However, the system is also expected to know the best learning strategies of students to generate recommendation that will help students to better understand their self. The recommendation is generated by using various parameters such as post-test scores, learning strategy evaluation values, learning strategy access time, number of clicks and number of summary words to determine the best level of metacognition and learning strategies for students. The learning strategy recommendation system developed using Simple Additive Fuzzy Weighting Algorithm. This method adds the weight of each criterion in each learning strategy. The system's functionality is tested using Black Box method as well as validated by experts. A user acceptance test (UAT) is also carried out to prove that the system is accepted by users and requirements have been met. The UAT resulted in an average of 82.5% which is considered as very good.

KEYWORDS

Metacognitive training system, self-regulated learning, recommendation system, e-learning.

1. INTRODUCTION

A metacognitive training system (MTS) is a system to train students' metacognitive skills and self-regulated learning (SRL). Previously, an MTS which is aimed to support students in learning algorithm and data structure was developed. The developed MTS provides some different learning strategies, namely drawing, summarizing, and controlling video to be used by students according to their individual preference (Nurlayli, Adji, Permanasari, & Hidayah, 2017). The first learning strategy, i.e. drawing, is a strategy that gives students a learning material which is complemented with a tool for drawing a mind map about the learning topic. The second strategy is summarizing in which students will be provided with tool for summarizing the learning material into a short paragraphs. Lastly, controlling video learning strategy, it is a strategy that gives students a video complemented with controlling tools.

Given the three learning strategies, students are free to use one of them. After that, they must evaluate the effectiveness of the strategy and revise when needed. Therefore, students are encouraged to identify the best strategy for each of them. However, it is found in the testing phase that students need a learning strategy recommendation system to further support their learning (Nurlayli, Adji, Permanasari, & Hidayah, 2017). It is expected that the system can provide insight of the most appropriate strategy for each student in practicing metacognition and self-regulated skills in the learning process.

Therefore, the aim of this current study is to design, develop, and evaluate a system which generates learning strategy recommendation for each unique student. To generate the recommendation two types of parameters are used, including offline and online parameters. Offline parameters in this case are collected by the use of self- report questionnaire. The questionnaire is used as a self-report instrument to evaluate previous learning strategies. Online parameters are composed from two components. First component of online parameters are the log of user interactions when using a learning strategy, such as the number of clicks, the number of words and the study duration. The second component is the result of learning outcome assessment.

2. LITERATURE REVIEW

Metacognition is an important success factor for student learning. When someone has reached a good level of certain metacognition, a person can do self- regulated learning (SRL), which is how a student can be a self-regulator for his own learning. SRL also means monitoring of behavior in the learning process as a result of the metacognition process of goals, planning, and self-appreciation for the achievements that have been achieved (Zimmerman & Pons, 1986) (Poitras & Lajoie, 2013).

One of the support systems in increasing the level of metacognition and SRL is the metacognitive training system (MTS). With MTS, the process of improving metacognition can be done during the learning process. Presently, metacognitive training systems are developed in several learning topics, such as biology (Azevedo, Johnson, Chauncey, & Burkett, 2010) and mathematics (Cueli, González-castro, Krawec, Núñez, & González-pienda, 2016). However, for engineering disciplines, the implementation of metacognitive training system is hardly found. Algorithm learning as a fundamental course in information engineering school is emphasized to develop the ability to analyze computing problem and to design a possible computing solution. Thus, metacognitive training to be implemented must support the development of problem-solving skill (Combefis, Barry, Crappe, & David, 2017). Furthermore, the presence of recommendation from the system will guide and ensure the effectiveness of the training system.

Recommendation systems are developed based on users profile or model (Santos & Boticario, 2015). Where, student model is the simplified representation of the student which defines the character of the student. There are several machine learning techniques for student modeling, such as fuzzy inference system (Hidayah, Permanasari, & Ratwastuti, 2013). Fuzzy inference system has been demonstrated to improve adaptivity of e-learning systems. Therefore, the technique is going to be explored in this study.

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3. METHOD

The simple additive weighting (SAW) method is a method of adding the weight of each parameter used in a study. The basic concept of this method is to add up the weighting of the performance rating on the alternatives available on all attributes. The SAW method requires a normalization of the decision matrix and the weights. This method has 2 attribute criteria, which are profit criteria and cost criteria. The benefit criteria have a greater value if the level of compatibility is higher. The cost criterion will have a smaller value if the compatibility level is higher. The SAW method is often used in solving multiple attribute decision making

problems as in this study (Fahrurrozi & Gautama, 2013). The equation for computing SAW is in (1), where V_i is the value of user's preference on each alternative.

$$V_i = \sum_{j=1}^{n} w_j r_{ij} \quad (1)$$

Learning strategy evaluation questions are questions compiled which is aimed to get feedback from users after using a learning strategy. This evaluation question is displayed when students complete a learning step by using his/her learning strategy. These evaluation questions are based on (Talby, Nakar, Shmueli, Margolin, & Keren, 2005; Permana, 2017) regarding collaborative applications in e-Learning strategies. These questions are listed in Table 1.

Table 1. Questions for self-evaluation on used learning strategy

No	Question
1	Are you confident in using this learning strategy?
2	Does the learning strategy provide information that can be easily understood?
3	Can you collaborate with the learning strategy?
4	Are you innovated to learn more when using these learning strategies?
5	Have your learning objectives been achieved with this learning strategy?
6	Did you get feedback from the learning strategy?
7	Can you feel focused when using the learning strategy?
8	Are you encouraged to use the learning strategy again?
9	Can you conclude the learning material learned from the learning strategy?
10	Do you understand texts, pictures or videos based on these learning strategies?

Each question has been considered by the developer according to the needs of the recommendation system. The first question was chosen to find out the ease of receiving information from learning strategies to students. The second question is made to find out the material and learning strategies that are of interest to students. The third question was chosen to find out the resilience and level of focus of students in using learning strategies. The fourth question is the most important chosen to find out the students' interest in using learning strategies. The fifth question was chosen to find out the continuation and development of learning strategies going forward. The sixth question is to determine the ability of students to take the essence of the learning strategy undertaken. These five questions have been considered against the factors associated with e- Learning system feedback (Talby, Nakar, Shmueli, Margolin, & Keren, 2005).

User acceptance test (UAT) is a formal test carried out to determine system acceptance from the user's point of view. The accepted system meets the acceptance criteria based on the user Hambling & Van Goethem, 2013). UAT has three main contributions as follows:

1. Complete the system requirements with direct verification with the user.
2. Reveal other problems that have not been found in the system for continued system development.
3. Gives the completed status on the system that the user has accepted.

In developing the system, a UAT survey questionnaire will be used aimed at the user. The questionnaire that is based on Hambling & Van Goethem, 2013) can be seen in Table 2.

Table 2. Questions for user acceptance test (Hambling & Van Goethem, 2013)

Question	A	B	C	D	E
Is this learning web look interesting?					
Are the learning web menus easy to understand?					
Is this web learning media material easy to understand?					
Are there examples that help understand the material?					
Is the evaluation on this learning web appropriate?					
Does evaluation help measure material understanding?					
Can this web learning media be used as a learning aid media?					
Is this web learning media good enough?					

Each question has 5 answer options from A to E. Information on the answer options can be seen in Table 3. The answer options have different weights in accordance with the provisions of the UAT weighting table. Answer A has a weight times 5, B has a weight times 4, C has a weight times 3, D has a weight times 2, and E has a weight times 1.

Table 3. Definition on each option of the answer in UAT

Option	Definition
A	Very: easy/good/appropriate/clear
B	Easy/good/appropriate/clear
C	Neutral
D	Fair: easy/good/appropriate/clear
E	Very: difficult/bad/inappropriate/unclear

This test requires at least 15 respondents to obtain the ideal acceptance results (Halimah, 2010). In the test, there will be a survey of at least 15 students who have taken the Algorithm and Data Structure courses from various forces.

4. RESULT AND DISCUSSION

The use case diagram of the recommendation system can be seen in Figure 1. It presents a picture model of various functions and interactions that can be operated by actors in the developed metacognitive training system. Meanwhile, some activities in the system can be executed in order or not. In making it easy to understand the sequence of activities from beginning to end, all activities in the system are described in the Activity Diagram in Figure 2.

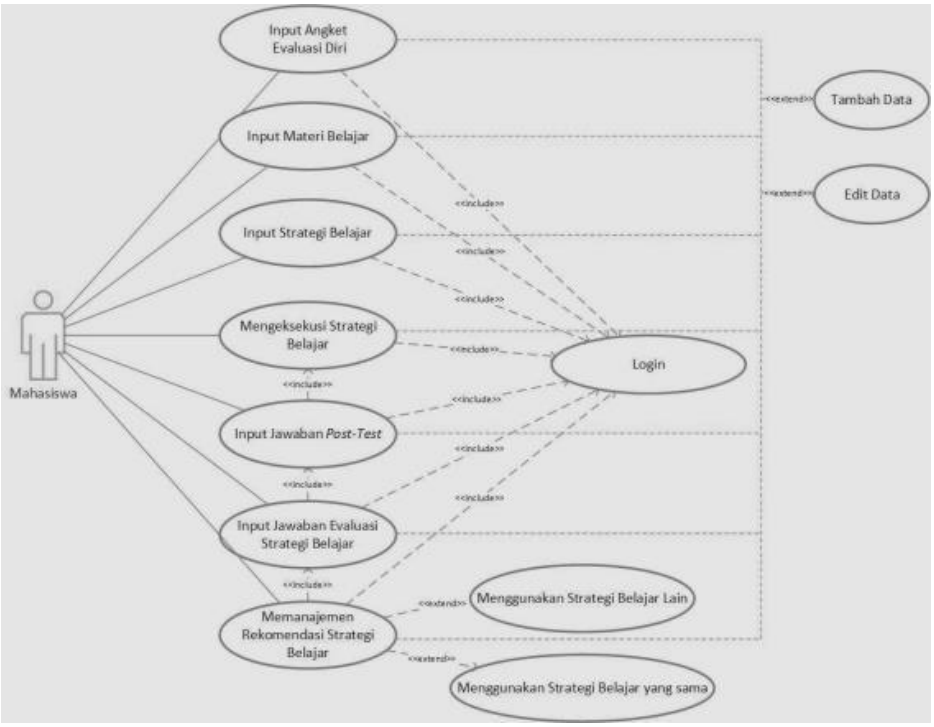

Figure 1. Use case diagram

As shown in Figure 2, login activity is carried out to open the functions and features in it. When a student successfully logs in, the system will display the Self Evaluation Questionnaire page and the student will fill in the Self Evaluation Questionnaire and the system will store it in the database. After that, the system will direct students to a page that contains learning material offered and students will input the desired learning material. If you have inputted learning material, the system will direct students to a page that lists the learning strategies offered. The list of learning strategies that are displayed will be chosen by students and the system will store the results of the input into the database.

The learning strategy recommendation system was developed using 2 decision making methods, namely by using a decision table and the Simple Additive Fuzzy Weighting (SAFW) algorithm. The Decision Table will establish a recommendation system based on student statement and grade in each criterion used in each learning strategy and the SAFW Algorithm maps the "gray area" of the total criteria value that is still unreached by the decision table such as students who get the middle criterion value on each criteria. The Decision Table has applied Fuzzy Logic to certain criteria so that there are not only pass and not pass. SAFW algorithm can be said as an amplifier of the decision table.

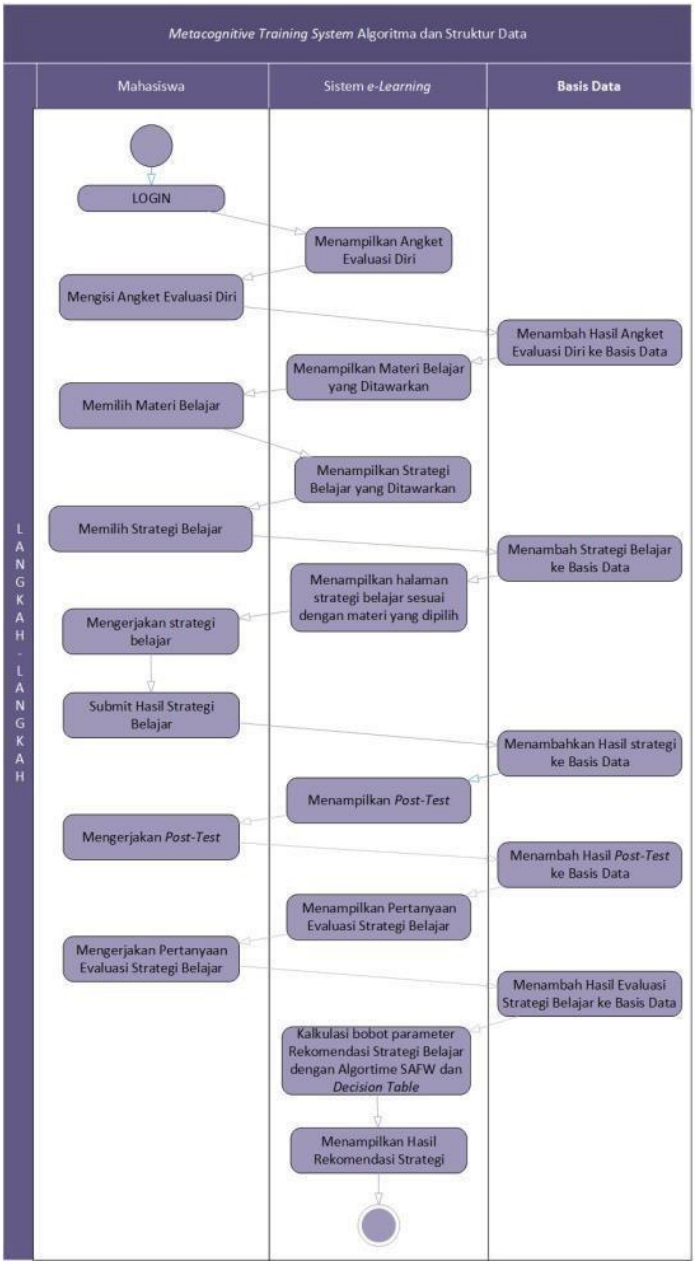

Figure 2. Activity diagram

The most difficult part in the study is in defining the value of the criteria, because there is no previous research on the learning strategy recommendation system using user behavior criteria. For example, we need to use number of clicks as an indicator for match/no-match with a learning strategy, e.g. controlling video. To answer this question, a survey is conducted which resulting in some values as listed in Table 4. For example, a student make 17 of clicks when using a controlling video learning strategy, thus, he can be categorized as medium match to the strategy.

Table 4. Relation of number of clicks and categorization of match

Learning strategy	Low	Medium	High
Video	0-4 and >36	5-9 and 16- 35	10-15
Draw	0-25 and >70	26-35 and 46-70	34-45

Data log of students' interaction with the system are recorded the results of each of these criteria and calculate the Simple Additive Fuzzy Weighting algorithm.

The calculation of UAT results of question number 1 is 70.5%, question 2 is 78.8%, question 3 is 82.4%, question 4 is 82.4%, question 5 is 89.4%, question 6 is 91.7 %, question 7 is 84.7% and Question 8 is worth 80%. The result indicates that the recommendation system has an attractive appearance, the menus on the web media are quite easy to understand, the content or material is easily understood and understood with examples of material, evaluations are already available, this web learning media can also be used as a media learning aids and learning media web is good.

5. CONCLUSION

Based on the evaluation result, the learning strategy recommendation system can adjust student preferences. Several criteria such as post-test, learning strategy evaluation questions and user behavior such as the number of clicks, the number of words and the amount of time can be used to determine the learning strategy recommendations.

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