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Concept Enhancement of Undergraduate Students in Static Fluid by Using Assisted Web-Based Recitation Program

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Abstract. This study investigated the effect of assisted web-based recitation program of undergraduate students' concept enhancement in static fluid. It is a follow up analysis of our previous work. The mixed method with embedded experimental design was utilized with 24 undergraduate students of Physics education Universitas Negeri Malang enrolling in introductory physics course. The quantitative and qualitative data were collected by written test (pretest and posttest) with 12 reasoned multiple choices questions to analyze the students' concept enhancement after using assisted web-based recitation program. The data was analyzed with Wilcoxon signed-rank test, N-gain, d-effect and N-gainlike. The result showed that assisted web-based recitation program led to statistically significant increase in the students' concept understanding, especially in the concept of static fluid with d-effect size of 1.81 and N-gain of 0.23. In fact, this study also still found that students had difficulties in mastering some fluid static concept.

INTRODUCTION

There are several theoretical viewpoints that explain students' conceptual changes that can be considered in overcoming and explaining student learning difficulties or make scientific explanation about a natural phenomenon, i.e. misconceptions theory, resource theory, and ontology theory [1]. Misconception theory and Ontology theory is about the view that difficulties arise due to students' confusion which is difficult to change because they have been constructed by students through long experiences. Therefore, according to these two theories, mistaken student conceptions should be discarded and replaced with new scientific concepts [2]. On the other hand, resource theory views that student difficulties occur due to the inconsistencies of the use of resources [3] and students' failure to activate cognitive resources which are appropriate to the context of the problem [4]–[6].

It is important for a teacher to know the cognitive resources that students use to understand a phenomenon. In particular, the role of educators is to provide students with learning opportunities to create as many resource-context associations as possible that are known to be true, while at the same time weakening the incorrect pattern of resource-context associations [5], [7]. Students are deemed to have mastered the concept if they are able to learn and apply the concept to the problem-solving process [8] in particular to the solution of many types of problems. Nonetheless, the facts show that students still have difficulty in understanding concepts [9]. This suggests that encouraging students to master essential concepts is not a simple matter. Apart from the existence of misconceptions and failures in activating appropriate resources, mastery of student concepts is also influenced by time constraints.

It takes so much time to enhance students' concept by providing as much as possible the opportunities to establish the correct pattern of resource-context association, that it might not be dealt with in the lecture section. Teacher needs to pay attention to any kind of student thought and provide sufficient feedback [10]. We have developed a web-based recitation program in fluid mechanics adapted of some previous relevant findings [7]. We have tried to implement the program in two groups, the first group used the program accompanied by an assistant and the second group used the program independently without an assistant. The result has shown that the web-based recitation program was successful to improve the students' conceptual understanding of fluid mechanics and can be used equally well with or without direct assistance from assistant.

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This study is a part of our previous work. The aim of this study is to analyze or investigate a deep proof about the effect of assisted web-based recitation program of undergraduate students' concept enhancement, especially in static fluid.

METHOD

This study is a part of a project on exploring students' conceptual understanding through the development of web-based recitation program. The study used a mixed method with embedded experimental design. To enhance the result of study, the quantitative and qualitative data was integrated [11]. Quantitative data was obtained from students' pretest and posttest scores while qualitative data obtained from observation and students' reasoning on their pretest and posttest answer. The participant in this study was 24 undergraduate students of physics education Universitas Negeri Malang enrolling in introductory physics course at 2019/2020 course year. The assisted web-based recitation program was implemented in this study. It is the recitation class led by teaching assistant by using website to facilitate students deepen their understanding of static fluid concepts exposed in the lecture section. Brief description of web-based recitation program has been explained in our previous article [7].

This study began with qualitative investigation which revealed the students' difficulties in understanding static fluid concept. Students performed a written test (pretest and posttest) before and after intervention (implementation of assisted web-based recitation program). Students performed a pretest directly after learning static fluid topic in the lecture section. The posttest was then administrated directly after the intervention had been completed. Pretest and posttest used the same instrument, consisting of 12 multiple choices conceptual questions with reliability 0,54.

The intervention took place in 2 weeks with 2 meetings, each lasting 90 minutes. At the first meeting, students learn about Hydrostatic pressure and Pascal law, then in the second they learn about Archimedes principles. All meetings provided a website program consists of some multiple-choices conceptual question followed by immediate feedback. In addition, students are queried to work on the quizzes and record their answers on the answer sheets in order to find out their basic knowledge before learning by using the web-based recitation program. The Assistant provided guidance to all students who need an in-depth explanation, and allowed students to ask questions when they are facing difficulties. Classes were designed to be as comfortable as possible, so that students could study and work on recitation program with a focus but remain relaxed. Generally, the learning sequence is shown by Figure 1.

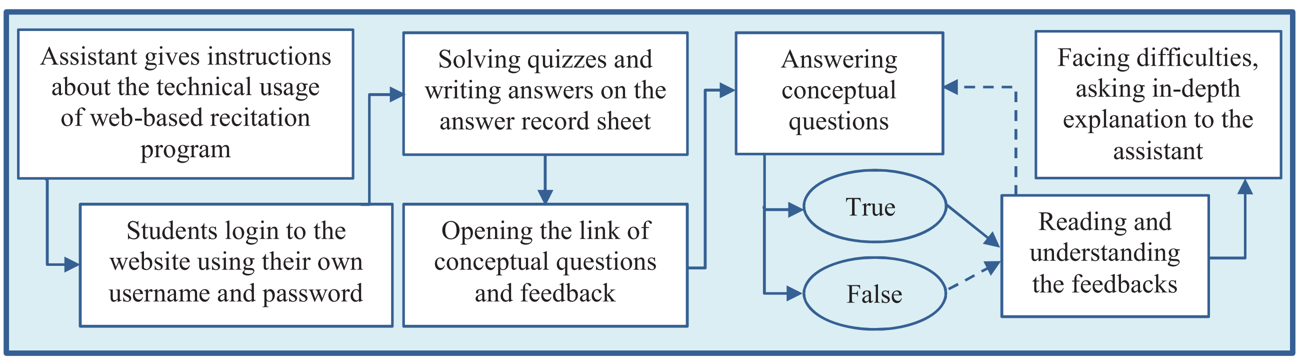

FIGURE 1. General Sequence of Learning by Assisted Web-Based Recitation Program

Analyzing the data was done by using descriptive statistics includes the average, standard deviation, minimum score, maximum score, Standard Deviation (SD), and skewness. The data normality was known from the skewness value. Data considered not to be normal distribution, so we used Wilcoxon Signed Rank Test to determine the difference between pretest and posttest score, which is significant or not. Last, we calculated normalized gain (N-gain) [12] and d-effect size to determine the effectiveness of assisted web-based recitation program to enhance students' conceptual understanding in static fluid. The students' conception that improved most after using assisted web-based recitation program as a study aim can be identified on the basis of the proportion of students who responded correctly to the posttest compared to the pretest on each question item. Since the calculation is almost the same as the N-gain calculation of individual student scores [13], we called the N-gainlike calculation. The following is N-gainlike equation.

$$<g_{like}> = \frac{Correct\ number\ of\ posttest - Correct\ number\ of\ pretest}{Total\ student - Correct\ number\ of\ pretest}$$

The categorization of N-gainlike value in this study is adapted from Sutopo and Waldrip [14]. If the N-gainlike value of each item is in the high or upper medium category (N-gainlike ≥ 0.45), it means that the students' ability in the question has been successfully enhanced. Some questions that have N-gainlike according to the upgrade category are discussed in depth with justification from qualitative data (students' reasoning on the pretest and posttest answer).

RESULTS AND DISCUSSION

The descriptive statistic of pretest, posttest and N-gain scores are presented in Table 1. The average of pretest score is 7 with SD 1.351 and the average of posttest score is 9.427 with SD 1.316. It seems that the average of posttest score is far higher than pretest. Considering to skewness value, the pretest skewness is not normal distribution because it is less than -1 [15]. Then, Wilcoxon Signed Rank Test is applied.

TABLE 1. Statistical Description of Pretest, Posttest and N-gain Scores

Statistics	Pretest	Posttest	N-gain
Number of Data (N)	24	24	24
Minimum Score	3	7	0.00
Maximum Score	9	12	0.50
Average	7	9.427	0.231
Standard Deviation (SD)	1.351	1.316	0.155
Skewness	-1.269	0.135	-0.145

Note: Score Interval is 0-12

The Wilcoxon signed-rank test revealed that there were significant differences between mean score of pretest and posttest with z = -3.865, p = 0.000. The value of d-effect size (d = 1.81) in the category of "very high" [16] and N-gain value is 0.231, in the category of "low". It means that assisted web-based recitation program applied in this study provided strong positive impact of students' concept enhancement in static fluid topic but in low level enhancement.

TABLE 2. N-gainlike on Each Question Item

Question Number	N-Gainlike	Category	Evidence
1	0.87	High	Increased
2	0.65	Upper-medium	Increased
3	0.00	Low	Decreased
4	1.00	High	Increased
5	0.90	High	Increased
6	1.00	High	Increased
7	0.09	Low	Increased
8	0.38	Lower-medium	Increased
9	0.00	Low	Decreased
10	1.00	High	Increased
11	0.14	Low	Increased
12	0.40	Lower-medium	Increased

Table 2 shown the N-gainlike value in each question item, it is about half of the question items which have high N-gainlike and upper-medium categories. Among them is question number 1, 2, 4, 5, 6, and 10. To justify the enhancement of students' conceptual understanding, the following describes in-depth the change of student answers from pretest to posttest on two questions (number 1 and 6) and also analyzes the resources used by students in answering the test.

The context of question number 1 is that a boat is in a shipyard. Students are asked to compare fluid pressure at a variety of points in a shipyard. Data on Question 1 is shown in Figure 2.

Five points A, B, C, D, and E are on a horizontal line in a shipyard (see picture). When the water in the shipyard is very quiet, the right fluid pressure at a variety of points is ...

a. $P_D > P_C > P_E > P_B > P_A$
b. $P_A > P_B > P_C > P_E > P_D$
c. $P_A = P_B > P_C = P_D = P_E$
d. $P_A = P_B < P_C = P_D = P_E$
e. $P_A = P_B = P_C = P_D = P_E$

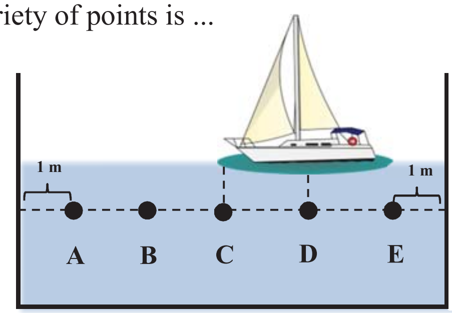

FIGURE 2. Question No. 1

The answers of the students during the pretest are varied in question 1. Based on the results of the pretest, 9 students (38%) answered correctly (Option E). Then two students (8%) responded to option C, and 13 students (54 percent) replied to option D. The crosstabulation is shown in Table 3. Students who answer to options C and D assume that the boat exerts additional pressure at point C, D, E. So that the pressure at points A, B and those at points C, D, E is different. This is definitely not in accordance with the concept of hydrostatic pressure that the depth of the pressure at the level of the fluid is affected. In addition, based on the Main law of hydrostatics it is stated that the pressure at points which are as horizontal and in the same fluid has the same pressure.

TABLE 3. *Crosstabulation* of Students Answer No. 1

		Posttest			Total
		C	**D**	**E***	**Pretest**
Pretest	**C**	0	0	2	2
	D	1	1	11	13
	E*	0	0	9	9
Total Posttest		1	1	22	24

*The correct option

The right resource to answer this problem is related to the concept of hydrostatic pressure and the main law of hydrostatics, the points which have the same pressure are those which are at the same depth, as long as they are in the same fluid and the fluid is connected. The change of student reasons in question number 2 is presented in Table 4. In the posttest there was 22 students (92%) answer correctly, another 2 students (8%) answer option C and D.

TABLE 4. The Summary of Students Reason for Question No. 1

Option	*Pretest*		*Posttest*	
	Student Reasons	**Total**	**Student Reasons**	**Total**
C	Pressure at points C, D, and E are greater than A and B because the boat exerts additional pressure.	2 (8%)	The main law of hydrostatics states that the amount of hydrostatic pressure at points that are parallel to the surface of the earth are equal. Therefore $P_A = P_B = P_C = P_D = P_E$	22 (92%)
D	Pressure at points A and B is greater, while at points C, D, and E are smaller.	13 (54%)		
E*	Because the points A, B, C, D, E are on the same line, so the pressure is the same.	9 (38%)		

In problem number 6 (Figure 3), the context is that there is an object (a coin of money) sinks to the bottom like a water tub. Students are asked to determine the normal force at the base of the coin. To solve problem number 6, students must be able to identify the forces acting on objects while in the fluid. In the matter explained that a coin had fallen to the bottom of a water tub, so that students' knowledge or resource related to the principles of Archimedes and Newton's law is applied. When sinking, the forces acting on a coin are the wight (the direction down), the lift force by water (the direction up) and the normal force (the direction up). Because the coin is in a sinking condition, Newton's first law applied, that the normal force (N) is the weight of the coin (W) minus the lift force of water (Fa).

6. A coin of 1000 rupiah is sinking to the bottom of a water tub. What is the normal force applied to the coin?
   a. Same as coin weight
   b. Same with water lift force to coin
   c. The weight of a coin plus the lift force by water
   d. The weight of the coin reduced by the water lift force
   e. Same with the weight of water whose volume is the same as the volume of the coin

FIGURE 3. Question No. 6

In the pretest the number of students who answered option D (correct answer) was quite a lot, 18 students (75%). While there was 1 student (4.17%) answered option A, 1 student (4.17%) answered option B, 3 students (12.5%) answered option C, 1 student (4.17%) answered option E. In the posttest, the number of students who answered correctly increased to 24 students (100%). This proves that students' conceptual understanding was increased. A summary of the students' reasons for each answer option is presented in Table 5.

TABLE 5. The Summary of Students Reason for Question No. 6

Option	*Pretest*		*Posttest*	
	Student Reasons	**Total**	**Student Reasons**	**Total**
A	When sinking objects are not lifted so that the normal force of the coin is equal to the weight of the coin $N = mg$	1 (4.17%)	A coin is sinking objects, then there are 3 forces that work, lift force (F_A), weight (W) and normal force (N) $N = mg - F_A$	24 (100%)
B	The normal force of a sinking coin is the same as the force of lifting water against a coin $F_A = mg$	1 (4.17%)		
C	The normal force is equal to the weight of the coin plus the lift force by water because the coin is in water	3 (12.5%)		
D*	The force that acts when sinking is lift force, weight and normal force $F_A + N = mg$ Then, $N = mg - F_A$	18 (75%)		
E	The normal force is the same as the volume of water transferred	1 (4.17%)		

Based on the results of statistical analysis and discussion of student answers during the pretest and posttest on a number of questions, there can be evidence that the assisted web-based recitation program developed is able to assist students in learning, particularly in fluid static. The value of N-gainlike on several questions in the high and upper-medium category. It can be assumed that the practices of conceptual questions and feedbacks in the program will enhance students' conceptual understanding [17]. Feedback is given immediately and repeatedly to strengthen students' correct understanding in various problem contexts. Furthermore, correct understanding will become a short-term memory that is easily and quickly activated when faced with similar problems [4] and students become experts [1]. Therefore, in developing web-based recitation programs, it is very important to provide a repetition of concepts presented in a variety of correct contexts.

The findings of our previous study were that web-based recitation programs was effective in to improve students' conceptual understanding of fluid mechanics, whether with or without direct assistant from teaching assistant [7]. Then, this study has provided proof that the class with direct assistant, especially on static fluid topic, students' conceptual understanding enhanced. It can be seen from a number of questions that have the high value of N-gain, d-effect, and N-gainlike in each item. Furthermore, it is reinforced by in-depth explanation of some question item along with the resources activated by students when answering the questions and if there was no change in a number of questions (e.g. Questions 3 and 9). This study also proves that there are still some difficulties faced by students in understanding the concept of static fluid with the use of assisted web-based recitation program. It equal to some previous studies that revealed students difficulties in understanding static fluid concept [18]–[21].

The findings of this study are consistent with the results of Koenig's [22] study who confirmed that the mastery of students' concepts was enhanced by the use of tutorial recitation program with a direct assistant. This has also been reinforced by several other studies which have shown that the practice of conceptual questions learned in program could enhance students' concepts mastery [23], [24]. Moreover, the feedbacks on each conceptual question option (whether true or false) can help students enhance their understanding, verify the truth students' conception [25] and sharpen their own conception [26].

There were many limitations in this study. First, while our teaching plan was implemented, some students were still not aware of the use of the web-based recitation program. They are just joining to program, reading the questions also the feedback briefly without deep comprehension. The next study should more concerned on students with this character. Second, the subject matter of the study was limited. Then, the generalization of the findings was also weak.

CONCLUSION

Our main finding revealed that the assisted web-based recitation program could enhance students' conceptual understanding in static fluid in line with our previous study. This can be seen from the increase of the pretest score to posttest, even from N-gain and d-effect score of 0.23 and 1.81, that the program is successful in increasing students' conceptual understanding. It's about half of the questions in high N-gainlike and upper-medium category. Many others in lower-medium and low category mean that students often found difficulties in mastering fluid static concept. Improvements and a detailed evaluation of the program are required. There is also a need to increase the number of conceptual questions and their feedback in order to cover more specific contexts.

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