The Influence of Sub-Microscopic Media Animation on Students' Critical Thinking Skills Based on Gender

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Abstract. This study aimed to examine the influence of sub-microscopic media animation on students' critical thinking skills in terms of gender. The study used pre-test and post-test control group design. The sample consisted of experimental group and control group, each of which consisted of 27 students (12 males and 15 females). The sampling technique used was purposive sampling. Data on critical thinking skills was taken using a description test on buffer concepts. Further data were analysed using a t-test at 95% significant level. The results showed that sub-microscopic media animation influence students' critical thinking skills, both male and female. In the experimental group, students' critical thinking skills are higher than male students, which means that sub-microscopic animation media influence female students' critical thinking skills better than male students.

1. Introduction

Technology has been growing so rapidly in just a few years. For education, technological progress has a very significant influence, such as changes in teaching and learning systems, ease of access to knowledge, bridging communication between teachers and students, and maximizing learning evaluation [1,2]. Especially in science lessons, technological sophistication is very helpful in the development of learning media with the existence of various computer applications [3-6]. The use of computer technology helped students increase their curiosity and open attitude [7], as well as students' creativity in the figural and verbal aspects [8].

Learning media acts as a tool that helps teachers convey information in this subject matter to students. Information in the form of material submitted without media assistance will make it difficult for students to understand it, including in studying chemistry. Among the three levels of representation (macroscopic, sub-microscopic, and symbolic), sub-microscopic levels are more difficult to understand because sub-microscopic representations explain the structure and process at the particle (atom/molecular) level of the observed phenomenon [9-11]. The particle level cannot be observed directly or with the help of the tool. The sub-microscopic aspect can be studied with the help of instructional media featuring simulations of particle animation to make it look real and easier to understand. The learning media is called sub-microscopic media animation. The use of animation contributes to students' conceptual understanding [12] and representational competences [13]. Chemistry teachers must make much effort to create an ideal environment for teaching and learning by incorporating computer-assisted methods [14].

One of the important tasks of teachers in the classroom is not only to provide knowledge to the students but to teach them how to learn and know about how rapidly proliferating information [15]. Somehow, we are surprised at how technology, communication, and information are growing so rapidly.
Information in a place that is very far away once we can know at once immediately. It is inconceivable that such an age will be found by future students, which will surely be more sophisticated than current conditions. Such a drastic change certainly has a negative impact. Therefore, we must prepare our students from now on. Students must be able to think critically in response to information and knowledge that is increasingly unlimited. Students should be able to sort the correct or wrong information and wisely criticize the progress of the times in the future. Many critical thinking skills are one of the most important soft skills because critical thinking skills can be used in a variety of disciplines and aspects of life, including when students enter the workforce [16,17].

The world of formal education that becomes a place to grow children until adolescents even enter adulthood need to place critical thinking skills as one direction in learning achievement. The student must be trained to develop his critical thinking skills while mastering the material he or she studies. Critical thinking is the appropriate use of reflective skepticism, and that is necessarily linked with a specific area of knowledge [15]. However, and more significant for the current task, critical thinking is an element in many levels and what we expect students to achieve at the end.

Critical thinking skills do not just belong to a person, to extend that critical thinking is exercised and drills [18]. Studying the Media of Sub-microscopic Animation means training students to understand the abstract concept and to process the concept so that it becomes more real and reliable. It is expected to train critical thinking skills, because critical thinking is trying to understand a subject, thinking about it, appreciating it, understanding the strengths and limitations of it and then developing a point of view on the subject.

Sex differences in science learning are interesting to research. Based on research on mathematics learning, students' thinking ability and academic achievement were different from female [19,20]. Differences in thinking ability of male and female students were also found in physics learning [21]. The conceptual understanding of the physics reviewed in the gender aspects shows the differences between male and female [22]. There was a significant difference between creative thinking skills, particularly fluency and elaboration, between male and female students in biology learning [23]. The gender differences in chemistry learning have not been much discussed. Therefore, this study aimed to analyze the influence of sub-microscopic media animation on students' critical thinking skills in terms of gender.

2. Method
This quasi-experiment research used pre-test and post-test control group design. The study population was all students of class XI IPA in SMAN 7 Mataram which amounts to four classes. The sampling technique used was purposive sampling with the aim of obtaining samples having the same initial capability. The number of male and female samples was also adjusted so as not to differ greatly thus affecting the data. The sample consisted of experimental group and control group, each group consisted of 27 students (12 males and 15 females). The experimental group students were treated in the form of learning using sub-microscopic media animation while the control group was not given that treatment.

At the end of the lesson, the two sample groups were given a final test to obtain students' critical thinking skills data. The instrument used was a description test on buffer concepts. The description test measured seven indicators of critical thinking skills, namely (1) focus on a question, (2) answer questions, (3) judge observation reports, (4) induce or judge induced results, (5) deduce or judge deduced results, (6) make and judge value judgments, and (7) attribute unstated assumptions. Score critical thinking skills between 0 and 20. The data were analyzed statistically with the help of SPSS 23 program, including normality test, homogeneity test, and hypothesis test. In addition, the normalized gain score (N-gain) data was also calculated so that the data acquisition improves critical thinking skills on each indicator.

3. Result and Discussion
The learning was done on the concepts of buffer solution as many as six meetings. The experimental group studied the concept of buffer solution using sub-microscopic media animation, while the control group studied the concept of buffer solution without using that media. Before the lesson begins, a pre-test was performed to determine students' initial critical thinking skills. The result of the initial data
normality test with Shapiro-Wilk analysis gets the significant value of each 0.200 for the experiment group and control group which means that data was normally distributed. The homogeneity test using Levene's Test obtained a value of 0.787 indicating no difference in variance between the control group and the experimental group. Furthermore, independent sample t-test yields a significant value of 0.556. Based on the data analysis it was concluded that the initial critical thinking skill of the experimental group and control group was not different before being given treatment.

Furthermore, post-test was given to the students to obtain critical thinking skill data after learning was complete. By comparing experimental and control group data it can be seen how the influence of sub-microscopic media animation on students' critical thinking skills. Data critical thinking skills were grouped into two, male student data and female student data (Table 1). Furthermore, the data were analyzed by gender at 95% confidence level.

**Table 1. Data of Students' Critical Thinking Skills**

| Criteria       | Control Group |         | Experimental Group |         |
|----------------|---------------|---------|---------------------|---------|
|                | Male          | Female  | Male                | Female  |
| Amount         | 12            | 15      | 12                  | 15      |
| Lowest Score   | 7.83          | 7.42    | 11.25               | 11.67   |
| Highest Score  | 14.92         | 17.83   | 16.25               | 19.33   |
| Average Score  | 11.69         | 12.94   | 13.44               | 15.37   |

Result of post-test data analysis critical thinking skill of male student, that was: 1) normality test with Shapiro-Wilk test obtained value 0.667 for experiment group and 0.387 for control group which mean that data was normal distributed, 2) Homogeneity test using Levene's Test obtained value equal to 0.551 indicating no difference of variance between control group and experiment group, and 3) hypothesis test with an independent sample t-test yielded significant value equal to 0.036 which mean there was a significant difference between the critical thinking skill of male group of experiment group and control group. The difference between the experimental group and the control group was only in the treatment so that it can be concluded that the difference in skills was caused by the use of sub-microscopic media animation in the learning process.

The influence of sub-microscopic media animation can also be seen in increasing the score in each indicator of critical thinking skills. Figure 1 shows the critical thinking ability of male who study the higher sub-microscopic media animation in all indicators. Indicator with the highest average score in both experiment and control group was indicator 6, make and judge value judgments. The biggest difference in critical thinking skills is seen in indicator 3, judge observation reports. While the smallest difference appeared in indicator 2, answer questions.
The same data analysis was also performed on female student data with the following results: 1) normality test with Shapiro-Wilk analysis obtained value of 0.150 (experimental group) and 0.278 (control group) which means the data of the two groups are normally distributed, 2) homogeneity test using Levene's Test obtained a value of 0.172 indicating the control group and experimental group was homogenous, 3) hypothesis test with independent sample t-test yields significant value of 0.032 which means critical thinking skills of female students experimental group was different from the critical thinking skills of female students control group.

When analyzed based on the average increase in each indicator, the students' critical thinking skills were higher than the control group students (Figure 2). Indicators who score the highest average of both the experimental group and the control group are the indicator 6, make and judge value judgments, as well as the male students. The indicator with the largest N-gain difference was indicator 7, ie attribute unstated assumptions. While the smallest difference was in the indicator 5, deduce or judge deduced results.
The result of the data analysis showed that the critical thinking skills of experiment group students are influenced by sub-microscopic media animation. Buffer solutions include abstract concepts with concrete examples. Although the phenomenon of the buffer solution can be observed visually, understanding the concept is not as simple as looking at an example. An animation is needed further to explain the molecular level of the phenomenon. Animation as one form of visualization is an important element in teaching, understanding, and making science ideas. Visualizations such as languages and other communication tools are effective in influencing one's cognitive thinking and capacity [24]. If the sub-microscopic aspect of the concept of chemistry can be well understood it will greatly assist the students in understanding the concept of chemistry as a whole [10, 25]. This applies to both male and female students. The knowledge gained through visualization can enhance deep understanding, hypothesize, reason, and solve problems [26]. One of the advantages of educational technology is that it can be readily used to support the development of critical thinking [27].

To strengthen the influence of sub-microscopic media animation on critical thinking skills, an analysis of male and female students data in the control group was performed. The results of the analysis of the data are: 1) the normality test with the Shapiro-Wilk analysis get the value of 0.667 (experimental group) and 0.150 (control group) which means the data of the two groups are normally distributed, 2) the homogeneity test using Levene's Test obtained value of 0.044 which shows the variance is not homogeneous, 3) hypothesis test with independent sample t-test yields significant value of 0.019 which means there are differences in the critical thinking skills of female and male students.

Broadly speaking, critical thinking skills of female students are higher than the students' critical thinking skills. As shown in Figure 3, female students excel at all critical thinking indicators. It found on a study that female is better than male in critical thinking [28]. The effectiveness of animation use depends on material content and gender. Female students have a better ability in learning animation media than male. This is because animation can help female students manage the cognitive input they receive rather than static media [29].

![Figure 3. Comparison of Average Score By Male and Female at Experimental Group](image)

Figure 3 also shows the difference in the scores of male and female in each indicator. The ability to focus on questions (indicator 1) and answer the question (indicator 2) of the male was almost the same as female students. The biggest difference in critical thinking lies in the ability to make and judge value judgments. This was consistent with the results of the studies, male students dare to make decisions even at risk without much consideration [30, 31]. Female students were just the opposite, more careful in making decisions and considering everything more when thinking. The causes of differences in some aspects of ability between male and female include hormonal, brain structure, cognitive processes, and
social processes that are considered to have a significant effect on male and male differences female [27].

Although the female has a higher average value of results than male, female tend to lack confidence in judging their own abilities. The level of self-confidence is even higher in boys, which is indicated by the perception of boys who are higher than female [31,32]. Other studies have different conclusions, the students' critical thinking skills are better than the critical thinking skills of female students [33,34]. Other research results show that the use of animation can remove the boundary between male and female abilities [35].

4. Conclusion
The conclusion obtained from this research was sub-microscopic media animation influence students' critical thinking skills, both male and female. However, female's critical thinking skills were better than male students, which means that sub-microscopic media animation had more influence on female students' critical thinking skills than male students, especially on the ability to make and judge value judgements. The ability of female students in focusing on a question and answer questions was similar to male students.

5. References
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