Investigating Students' Creativity Based on Gender by Applying Virtual Laboratory to Physics Instruction

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ABSTRACT

Creativity is one of important goals of education. Students' creativity can be enhanced in information technology-assisted classroom. This study investigated the increase of students' creativity as they follow virtual laboratory-aided physics classroom sessions. The research was conducted towards three classes in three different high schools. The subjects had studied about virtual laboratory-aided physics learning. Samples were selected using purposive sampling technique suggesting 34 male and 36 female students. The results showed an increase exhibited by all students in terms of verbal and figural creativity. Overall, the average increases on creativity were of 55.6% for female students and 52.2% for male students. Verbal creativity was higher than the figural one, which was indicated of 59.02 and 41.97 for each group. The level of verbal creativity achievement were of 55.5 for male students and 62.4 for female students, while in terms of figural creativity, the score was 44.4 for male students and 39.6 for female students. It was also revealed that female students performed higher verbal creativity than male students. On the other hand, male students had shown higher figural creativity than female students.

Keywords: creativity; gender; virtual labs; physics instruction

INTRODUCTION

Science education is aimed at guiding and training students' thinking skills. By learning science, students are expected to be able to solve problems and be ready to take part in the global competition. Rustaman [1] states that the vision of science education in a long term is to prepare learners with an ability to think critically, be creative, and other skills considered as basic skills to engage in a scientific work.

Science has been developed into various independent branches. Physics, as one of the branches, consists of knowledge, concepts and ideas having important role in technology development. In fact, most of developing technologies are the applications of physics. Considering its central benefits, therefore, the quality of physics learning needs to be improved perpetually that encourages maintaining real efforts and innovations. According to Lindstrøm & Sharma [2], studying physics is concerned with gaining an understanding of basic concepts and becoming an expert to know when, how, and why physics is applied.

Physical learning in schools tends to indicate teacher-center protocol. As the result, student's activity is commonly restricted to listening, taking notes, and working out the teacher-prepared exercises. Students generally adjust the way they learn according to test-base model set by their teacher. They memorize a theory or mathematical equations to meet the need of facing a test. Therefore, only skimpy opportunity for them to produce creative expression and exploration, which in the end causes low level of creativity.

One of the obstacles in teaching physics is lack of adequate equipment to conduct experiment. Problems emerge when tools are not available, which causes difficulties for teachers to manage necessary experiment courses. Meanwhile, conducting experiment is very essential of learning physics, especially to develop learners' awareness towards process aspects and scientific attitudes. Students can learn how to measure, assemble tools, hypothesize, analyze data, create reports, work in teams, and some other skills. This issue should be solved immediately.

The development of computer technology provides opportunities for courses to manage virtual experiments. The activities can be conducted online or offline using an appropriate program. However, the use of computer simulations in virtual experiments is not intended to supplant the role of tangible laboratory equipment, but rather it becomes an alternative to respond the unavailability of real laboratory equipment for physics courses.

One of learning difficulties confronted by students in learning physics is to comprehend various abstract concepts. Thus, the use of virtual labs may help them to visualize the abstract concepts, which may assist students with a better comprehension. Beyond that, the course employing virtual laboratories can also ease students in building better concepts compared to conventional classroom [3]. Mutlu & Sesen [4] reveal that virtual labs can improve students' science process skills. A study by Tüysüz [5] also reveals that the use of virtual laboratories can also improve students' learning achievement and have a positive impact on them. According to Shyr [6], to support the view of allowing teachers to customize curriculum, virtual labs enable students to develop their own programs and identify problems related to their implementation.

The use of virtual labs in various models of learning has proven to increase students' creativity in physics learning [7,8]. Creativity is a basic human nature. In learning, creativity arises spontaneously through the relationship and interaction between teachers and students in a very specific and challenging situation [9]. One of the goals of creative teaching is to create a learning environment that enables students to imagine freely within a student-centered classroom, multimedia-assisted learning, classroom management, connect topic of instruction to real life situation, open-ended questions and encouragement for creative thinking [10]. Creativity involves discovery, curiosity, imagination, experimentation and exploration [11].

Rawat et al [12] reveals that creative people are the ones who are able to form judgments appropriately and are able to turn facts into ideas and then be able to sort out the ideas in detail. Meanwhile, Wyse & Ferrari [13] assert that creativity can be developed in learning to enact something valueable.

The purpose of this study is to compare the increase of student's creativity based on gender. Improvement is measured after students follow virtual-labs-assisted activities in physics course. This research is important to get empirical evidence related to finding significance of male and female students in the increase of creativity after given treatment. Literature and study related to measurement of creativity comparison

between male and female students after virtual labs treatment in physics learning is still rare. Only a few of literature reports the differences in male and female students' learning outcomes. Zhu [14] claims that there is a gender-driven influence for students in solving math problems. Many variables encourage this gender-driven differences, which includes environmental and psychological factors of each student. A study by Bacharach et al. [15] shows the gap of student achievement across gender.

METHODS

This quasi-experimental study engaged three classes in three different senior high schools. The subjects were selected using purposive sampling technique suggesting 34 male and 36 female students. Not all students in treatment class were taken as subjects. Students were picked up based on male-female students conformity in their initial ability to avoid too different in number of both groups. Each student had to deal with preliminary and final tests. After the initial test was given, each class was treated with virtual lab assisted learning, set into eight sessions. The final test was given after the lesson.

The test, which was designed as essay question, used to measure the level of creativity consisted of 10 items, which covered verbal and figural creativity test. Increase of creativity is determined by a calculation finding score of N-gain. The calculation was based on a formula, as follows [16]:

$$\frac{S_{post}-S_{pre}}{S_{max}-S_{pre}} x\ 100\% = N - gain \quad (1)$$

Description: N-gain> 70% (high); 30% ≤ N-gain ≤ 70% (medium); and N-gain < 30% (low).

RESULTS AND DISCUSSION

This study aims at comparing the increase of students' creativity based on gender, which is measured after students attend virtual labs-assisted physics courses to find both verbal and figural creativity level. Figure 1 shows different increase of creativity between male and female students from three schools.

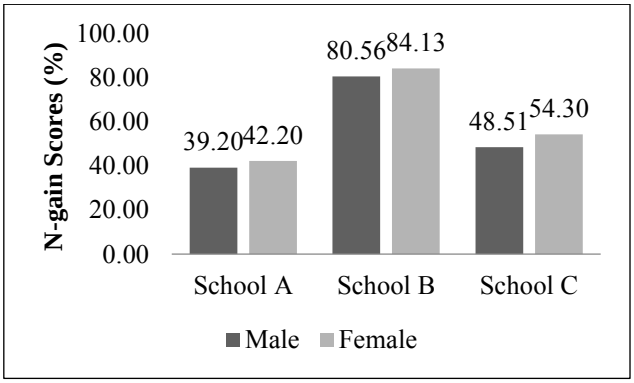

Figure 1. Differences between male and female students in the increase of creativity in three different schools.

Overall, the increased level of creativity in female students is higher than the male, which happens in all three schools. The average increases on creativity were of 55.6% for female students and 52.2% for male students. The highest result us shown by school B (high), while the other two schools achieve medium level. Despite the fact that female students are superior to male students, the difference is not significant. However, the difference between male and female is sufficient to prove that female students have superior physics creativity than men after treatment given. This finding supports Wang's [17] research exploring relationship of creative thinking ability in reading and writing, in which female students demonstrate higher scores than male in terms of creativity.

In addition to find out more comprehensive comparisons of average increased creativity, this study also compares every aspect of verbal and figural. The result of comparison in three schools is shown in Table I.

TABLE I. COMPARISON OF VERBAL AND FIGURAL CREATIVITY OF MALE AND FEMALE STUDENTS

Schools	Verbal		Figural	
	Male	Female	Male	Female
A	50.3	55.6	23.3	23.8
B	81.0	84.7	65.6	62.5
C	44.5	56.5	55.0	45.5
Average	55.5	62.4	44.4	39.6
	59.02		41.97	

As shown in Table I, it is known that increase in verbal creativity is higher than figural creativity of all students in three schools, yet male students of school C show different result. Increase of verbal creativity is found in medium category in school A and school C, while students in school B demonstrate high category. On the other hand, improvement of figural creativity is found low in school A and medium in school B and school C).

Female students experience a h igher increase than male in verbal creativity suggesting that female students have more flexible abilities in the formation of ideas through words, as well as directing the focus of problem to communication issue. In school B and school C, male students' enhancement is detected higher in terms of figural creativity meaning that male students tend to have higher abilities in the formation of ideas by combining patterns of shapes or images given. These findings are conformable to Matud et al. [18], who find male students in secondary education have statistically higher scores on t he aspects of figural authenticity, while in higher education female students score higher on the aspect of verbal fluency. Naderi et al., [19] states that the average female score is higher than the average male score on the aspects of environmental sensitivity, self-power, intellectuality and individuality, but the average score for female is lower than male in terms of initiative and art. This finding also supports DeMoss et al. [20] suggestion that female and male are different significantly in verbal components, in which female shows significantly higher score than male. High verbal creativity is associated with lower level of depression and positive attribution style.

Another study by Cheung & Lau [21] shows slightly different things. A study in secondary school shows that female students are better in verbal flexibility, figural fluency, figural flexibility, figural uniqueness, and figural unusualness. In addition, Rodzalan & Saat [22] state that in terms of gender differences, male students are more competent thinkers and problem solvers than female students.

Further result of the current study shows that students in school A demonstrate relatively low increase of figural creativity, in which both male and female students score quite similar result with a quite minor difference (only 0.5%). This finding is due to the fact that students in school A yet accustomed to solve physics problems dealing with figural creativity test compared to other two schools. In the end, it shows the magnitude of the influence of habituation and exercise to boost up students' creativity.

Meanwhile, if a more in-depth analysis of verbal and figural creativity of male and female students is conducted based on their initial ability, the result is quite interesting, as shown in Table II.

TABLE II. COMPARISON OF MALE AND FEMALE CREATIVITY IMPROVEMENT BASED ON INITIAL ABILITY

School	Gender	Initial Ability					
		High		Medium		Low	
		Verbal	Figural	Verbal	Figural	Verbal	Figural
A	Male	43.00	19.90	52.80	21.50	53.80	29.60
	Female	54.60	30.30	56.10	21.40	56.00	41.80
B	Male	85.28	62.50	82.93	68.75	72.92	62.50
	Female	89.33	62.50	82.73	62.50	84.24	62.50
C	Male	28.10	52.60	50.00	53.30	54.00	59.10
	Female	63.70	43.80	51.90	59.30	53.80	33.40

Table II shows that students with high initial abilities in the three schools have lower verbal creativity than students with moderate and low-skilled abilities after engaging treatment sessions. Highly skilled male students in school A have lower verbal creativity than students with moderate and low initial skills, similar thing is also demonstrated by female students. Similar case also happens to male students in school B and school C. On the other hand, female students of school B appear to demonstrate high-ability verbal.

In school A, the high-ability male students indicate the lowest figural creativity compared to those who have moderate and low initial ability. While among female students, the highest figural creativity is possessed by low-skilled female students. Furthermore, in school B, male and female students with initial ability have the highest figural creativity. In school C, the highest figural creativity of male students is demonstrated by those who have low initial ability. While in school C, among female students, the highest figural creativity is possessed by those who have moderate ability.

As part of the course, each student is given an opportunity to provide feedback, ideas and responses towards questions given by their teachers. Students are also required to make essential inquiries related to the proposed topic. In addition, students make a plan and design a draft of the plan based on topics given in virtual lab-assisted learning. This encourages students to be more verbally creative in interpreting ideas into words and proceed with further collaboration on the ideas.

Each student is given the freedom of giving and answering questions, creating ideas, making a plan and design, and elaborating ideas to be followed-up, which stimulates better verbal ability compared to the figural one. The more dominant figural skills appear in the preparation phase of the project according to worksheet facilitating learning achievements. Thus, the learning has implications of improving verbal skills, especially in female students compared to the male. Female students communicate more and put words into ideas or concepts than the male. A research by Kost et al [23] reveals that female prefers physics learning more than male, especially in comprehension of physics, as well as their learning behavior in classroom. The applied learning model asks the students to convey ideas (or concepts) verbally and further transform them into action, in which female students' verbal creativity is higher than the male.

In school B, male students with moderate ability experience the highest increase in verbal creativity up to 80.5%, which is quite similar to figural creativity. On the other hand, female students with high initial ability show the highest verbal creativity. The highest figural creativity is demonstrated by female students with low initial ability, while those who perform high initial ability demonstrate the lowest figural ability.

Table I also shows that female students with high and moderate initial abilities have higher verbal creativity than the male. Female students with high initial ability are able to elaborate verbal communication skills to solve a problem. They are less able to combine forms or images of a problem. While the male students are better in solving a problem based on form or image given.

Zhu [14] reveals that female has better verbal skills than male in terms of problem solving considering that female has better language skills and spatial abilities than the male. This is in accordance with the study of Usodo [24] which reveals that female does not prefer using direct intuition in solving problems. They prefer to analyze, make a plan, and provide global solution. This encourages the female to have higher verbal ability to the male.

In school C, male students with low ability experience the highest increase in their verbal and figural creativity. Meanwhile, female students with high initial ability demonstrate the highest increase in verbal creativity and those with moderate ability emerge with the highest increase in figural creativity.

Based on data of the three schools, it can be concluded that female students have higher verbal skills than male students in terms of the students' initial ability, including high, middle and low category. Meanwhile, most of male students' increase much higher in their figural creativity. Verbal and figural creativity can be enhanced by employing various types of instructional models. Besides that, selecting and employing certain media can also influence student creativity positively. This study proves that the application of virtual media in the three schools improves students' verbal and figural creativity.

The current study shows that male figural skills are higher than the female, which is relevant to a study by Shashaani [25] claiming that male students have greater computer experience than female students. The virtual laboratory used in this lesson consists of various images and animations to perform experiments, so that the male who have higher computer experience demonstrate a higher increase in solving problem using their ideas expressed in image patterns.

Significant differences in the increase of verbal and figural creativity among male and female are driven by environmental differences, including differences in

expectations, opportunities, types of experiences, and difference stimulated by interaction of talent, motivation, and opportunity [26]. The use of virtual laboratories improves student skills [27], as well as improves the disposition of critical thinking in physics learning [28]. The use of virtual media can also enhance student's comprehension on physics concepts [29,30].

CONCLUSION

The application of virtual media in physics learning has been effective to increase students' level of creativity, in both verbal and figural, of male and female students. The increase is shown by significant result of N-gain score of verbal and figural creativity in three schools, both for male and female. Female students demonstrate higher increase in verbal creativity, while the male students experience higher increase in their figural creativity. In three schools, the increase in verbal and figural creativity involves both male and female students although they start with different initial abilities.

The findings of this study would have the following implications. First, it empirically proves the influence of gender in every type of creativity that can be developed in physics learning with virtual labs. Second, the study reveals the effectiveness of virtual labs in improving students' creativity in physics learning in senior high school. Third, the results of the study show differences in the increase of each type of creativity in different gender. This is important for teachers to encourage them to teach physics creatively that is expected to improve students' creativity. Fourth, the findings of this study would reinforce the outcomes of previous research on the importance of familiarizing students with creative activities to encourage them to become creative people in the future.

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