Gender Analysis in Learning Physics in Terms of Student SEPs Skills and Creative Thinking

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ABSTRACT

Science and Engineering Practices (SEPs) skills and creative thinking are essential competencies in this 21st century. These skills are useful in forming a superior generation to face the industrial revolution, 4.0's challenges. This study's purpose was to determine whether students' gender differences affected their SEPs skills and creative thinking. This research uses quantitative and qualitative analysis methods. This study involved 65 students, consisting of 17 male students and 48 female students from senior high schools in the Boyolali Regency, Indonesia. SEPs skills and creative thinking were measured using work and energy material. SEPs skills employed 13 TTMC questions developed based on the California Science Test Practice and analyzed using the Graded Response Model (GRM). Meanwhile, creative thinking skills utilized seven descriptive questions and scrutinized them using the SSCM model proposed by Hu & Adey. The results revealed that male students' skills (SEPs and creative thinking skills) were better than female students.

Keywords: Gender, SEPs, Creative Thinking Skills, Science and Engineering Practices, Science Process Skills
Article Received: 18 October 2020, Revised: 3 November 2020, Accepted: 24 December 2020

Introduction

One of the teachers' challenges in the teaching and learning process in this 21st-century is to equip students with 21st-century competencies, which aims to prepare them to become successful individuals (Wijayanti, Sumarni, & Supanti, 2019). These must-have skills in this 21st century are named higher-order thinking skills. These skills encompass creative and critical thinking collaboration, innovation, and communication skills (Howard, Tang, & Austin, 2014); (Manzon, 2017); (Rotherham & Willingham, 2009).

These skills can be attained from school. For this reason, learning in schools must get attention, one of which in physics education development (Lazarro, 2015). Physics learning taught in schools strives to provide knowledge and develop students' thinking abilities (Gane & Pellegrino, 2018). Nevertheless, along with the current development that continues to advance and needs a quality generation, physics lessons also change, called next generation science standards, abbreviated as NGSS. The target of the NGSS is to increase student involvement in learning (NGSS Lead States, 2013)(Barakos, Lujan, & Strang, 2012).

Explicitly, one of the capabilities that students must have to reinforce the NGSS goals is the science and engineering practices skills abbreviated as SEPs skills. SEP is a change in science process skills (Atwood-Blaine, 2017) (National Research Council, 1996). SEPs are part of the future generation's science framework dimensions (Malkawi & Rababah, 2018). SEPs include eight indicators: asking questions and identifying a problem [sep-1], developing and using models [sep-2], planning and carrying out investigations [sep-3], analyzing and interpreting data [sep-4], using mathematics and computational thinking [sep-5], constructing explanations and designing solutions [sep-6], engaging in argument from the evidence [sep-7] and obtaining, evaluating, and communicating information [sep-8].

Another crucial skill for students in the 21st century is higher-order thinking skills. These skills are a necessary factor in achieving success in the future. One example of higher-order thinking concepts is creative thinking skills (Heong, Othman, Md Yunos, Kiong, Hassan, & Mohammad, 2011) (Heong, Lai, Tee, & Mohaffyza, 2016). Creative thinking skills are necessary because students can understand more complex information (Dwyer, Hogan, & Stewart,

2014) (Forawi, 2016). These thinking skills can make students perceive the world differently (Chalkiadaki, 2018). Indicators of creative thinking skills are fluency, flexibility, and originality (Treffinger, Young, Selby, & Shepardson, 2002).

Apart from the learning model, SEPS skills and creative thinking are often linked to students' gender. Gender is a category for sex, namely male and female. This gender issue is related to the way people act, think, and give reasons (Erkoc & Kert, 2013); (Peretomode & Bello, 2018). Principally, men and women have different experiences, talents, knowledge, and needs (UNESCO, 2014). Gender also influences some developments in scientific disciplines (Ujiro & Erhabor, 2017). In addition to the male and female students having different perspectives in describing their ideas, they also differ in solving a problem (Rachmatullah & Ha, 2019)

Several previous studies have examined the effect of gender on students' SEPs skills and creative thinking. Those study results revealed that gender did not affect students' science process skills (Ozturk, Tezel, & Acat, 2010). However, some also argued that female students' practical skills were better than males (Zeidan & Jayousi, 2015). There are also research results that showed that male students' practical skills were better than female students (Abungu, Okere, & Wachanga, 2014). It could also be seen from the students' creative thinking skills, as a researcher obtained the results that the male students' creative thinking skills were different from female students (Shubina & Kulakli, 2019). Another study uncovered no gender difference in students' creative thinking skills((Suprapto, Zubaidah, & Aloysius, 2018); (Thompson & Miller, 2017). It seems interesting to investigate whether there is an effect of gender on students' SEPs skills and creative thinking in learning physics in the Indonesian setting. Based on the above background, a study was carried out entitled Gender Analysis of Learning Physics in Terms of Students' SEPs Skills and Creative Thinking.

Literature Review

SEPs

SEPs are one of the dimensions of next-generation science standards (Malkawi & Rababah, 2018). SEPs are a change in terms of science process skills, which are used to build students' knowledge and solve problems (Maison, Budiarti, Christine Samosir, & Nasih, 2020). SEPs are closely related to practice, where students are required to be able to make hypotheses, analyze problems, do laboratory work and also do a project (Brand, 2020; National Research Council, 2012).

Creative Thinking Skills

The skills to use his thinking to create new ideas, new things, and develop ideas in more detail (Daud, Omar, Turiman, & Osman, 2012). The main characteristics of creativity are fluency, flexibility, and original ideas (Torrance & Presbury, 1984). To further elaborate on this, (1) fluency is interpreted as many primitive ideas, (2) flexibility is the ability to modify things that already exist and are no longer effectively used, and (3) statistically considered to be rare Happens, things that happen only occasionally or the answers are considered original (Hu & Adey, 2002). Creativity can also explain a skill that generates unique or unusual and unexpected ideas (Alrubaie & Daniel, 2014).

Gender

There is a category for sex, namely male and female. Male and female students have different abilities in qualitative fields Science (Yamtinah, Masykuri, Ashadi, & Shidiq, 2017). Gender Difference Literature in Science Education distinguishes male and female students about their interests, attitudes, scientific motivation, experiences, talents, knowledge, and needs (Britner, 2008; Mattern & Schau, 2002; Shemesh, 1990; UNESCO, 2014).

Methods

Sample

The type of research used was quantitative with descriptive methods. This research conduct in the 2019/2020 school year in senior high

schools in the Boyolali Regency. A total of 65 students consisting of 17 males and 48 females.

Instruments

The creative thinking skills test employed the SSCM test developed by (Hu & Adey, 2002). This test contained seven essay questions, covering three indicators: fluency, flexibility, and originality. The three indicators were associated with each other in the questions. Meanwhile, science and engineering practice tests measured by two-tier multiple-choice questions developed based on the California Science Test Practices. The SEPs questions comprised 13 questions with six indicators: SEP-1, SEP-2, SEP-3, SEP-4, SEP-6, and SEP-8.

Furthermore, the creative thinking skills test results calculated using a scoring rubric adapted from SSCM, developed by Hu & Adey. Meanwhile, SEPs skills calculated using the Graded Response Model method. Study results assessed using the SPSS 18 program.

Results

Data from the students' SEPs skills and creative thinking tests gauged and inspected, employing predetermined guidelines. The descriptive analysis results of scores for each aspect of creative thinking skills and SEPs viewed from the gender differences can be seen in Table 1.

Table 1. Scores of Students SEPs and Creative Thinking Skills

Skills	Gender	Mean	Max.	Min.
SEPs	Male	70.38	90	42
	Female	46.25	77	32
Creative Thinking	Male	65.74	82	55
	Female	50.29	68	38

Based on Table 1, it can be seen that the male students' SEPs skill mean score was 70.38, while the female student's score was 46.25. It indicated that the male students' SEPs skill score was higher than female students. The same thing occurred in creative thinking skills. The male students' mean score was 65.74, while the female students' mean score was 50.29. Hence, it could be said that the male students' creative thinking skill score was higher than female students.

Further, an analysis was carried out to determine whether there was a difference between male and female students' SEPs skills and creative thinking. This analysis used the SPSS 18 program, and the test employed was the covariance analysis test (ANCOVA). Some conditions must be met before performing the ANCOVA test; namely, the data must be normalized and homogeneous. Therefore, the normality test was performed using the Shapiro-Wilk test, and the homogeneity test utilized the Levene test. This study's normality and homogeneity test results can be seen in Table 2.

Table 2. Normality Test Results

		Shapiro-Wilk		
Skills	**Gender**	**Statistic**	**df**	**Sig.**
SEPs	Male	.964	17	.704
	Female	.981	48	.624
Creative Thinking	Male	.909	17	.097
	Female	.967	48	.190

Table 3. Homogeneity Test Results

	Levene Statistic	df1	df2	Sig.
SEPs	.152	1	63	.698
Creative Thinking	.050	1	63	.825

Based on the data in Table 3, it was shown that the significance value of the Shapiro-Wilk normality test was (p> 0.05) so that the data were said to be normally distributed. Homogeneity test Table 4 displays the significance value results of (p> 0.05) so that the data were homogeneous. After the prerequisite tests were fulfilled, the ANCOVA test was then performed using SPSS 18. The ANCOVA test results show in Table 4.

Table 4. ANCOVA test Results for SEPs and Creative Thinking Skills Based on Students Gender Differences

Dependent Variable: Gender					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig**
Corrected Model	7.560[a]	2	3.780	46.937	.000
Intercept	25.459	1	25.459	316.111	.000
SEPs	1.705	1	1.705	21.171	.000
Creative Thinking Skills	2.717	1	2.717	33.730	.000
Error	4.993	62	.081		
Total	209.000	65			
Corrected Total	12.554	64			

a. R Squared =.062 (Adjusted R. Squared = .589)

Table 4 exhibits the significance value of the creative thinking skills from the ANCOVA test of 0.000, and the significance value of the SEPs skills was 0.000. The two variables' significance was smaller than 0.05 ($p < 0.05$) so that the research hypothesis was accepted. It signified that there were significant differences between male and female students in SEPs and creative thinking skills.

Discussions

Based on the results of the study, it was concluded that the ability of SEPs and students' creative thinking in physics lessons experienced differences in terms of gender. Several prior studies are in agreement with this research. As (Abungu, Okere, & Wachanga, 2014) exposed, there were differences in the science process skill results between male and female students. (Opara, 2011) also unveiled that male skills were better than female students.

In detail, this study's results indicated that male and female students' SEP skills underwent differences. The difference could be seen from the mean score obtained by male students of 70.38 and female students of 46.25. These results suggested that male students' SEPs skills were better than female students. Supported by the significance value, this study resulted in 0.000 ($p < 0.05$). It is corroborated by the fact that males are better at learning science and mathematics, whereas female students are better at subjects, such as art and music (Elliot, Kratochwill, Littlefield Cook, & Travers, 2000). (Hazir & Turkmen, 2008)**,** also discovered that male and female students also experienced differences in experimental skills and scientific processing. Male students were more skilled in experimental activities and scientific processes. Based on the study results, the students' SEPs skills still need to be enhanced by an appropriate learning model, which is more innovative**.**

Besides, the results showed that male students' creative thinking skills were better than female students. The research that has been conducted indicated that the male students were more creative than female students. This result is reinforced by research results from (Zubaidah, Fuad, Mahanal, & Suarsini, 2017), which found that male students had higher creativity and innovation than female students in school. It could be seen in the mean results of all aspects of male and female students. It is also in line with what was stated by (He & Wong, 2011); (Matud, Rodriguez, & Grande, 2007). However, some researchers also disagreed with the research results, showing no influence of gender on differences in students' creative thinking skills (Bakir & Oztekin, 2014);(Kaufman, 2006) **;**(Tsai, 2013)

The difference in the score results of students' creative thinking skills was because male students preferred science lessons than females (Baer,

1997). Another reason is that male students are more skilled at solving problems and smarter in making decisions than females (Gok, 2014). Because of that, it can be used as a reason why men are more creative than women. It is also confirmed by a statement from (Gurian, Stevens, Patricia, & Terry, 2010) that the differences in male and female students' creative thinking skills or creativity are due to differences in their brains' anatomy.

Conclusion

Gender affects students' SEPs skills and creative thinking in physics learning. The results disclosed that male students had higher mean scores in SEPs and creative thinking than female students. Accordingly, this research needs to be informed to teachers who teach in schools. It is expected that with this information, teachers can plan lessons that can accommodate students' SEPs skills and creative thinking. Teachers must be able to stimulate students' skills because these two skills are essential in this 21st century.

Acknowledgment

The author would like to thank Sukarmin, S.Pd., M.Si., Ph.D., and Dr. Suharno, M.Si., for their assistance in completing this article.

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