Contribution of critical thinking, science process skills towards learning outcomes based on gender

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ABSTRACT

The purpose of this study is to ascertain importance of scientific reasoning and process abilities to students’ learning outcomes based on gender differences. This type of research uses the kind of correlation research. This research was carried out for one semester a sample of 104 students studying biology in senior high schools in Sumbawa, Indonesia, with a total of 55 female and 49 male students. In this study, multiple-choice examinations were used to assess the students’ science process skills as well as their critical thinking abilities and learning outcomes. The findings the results of the multiple regression analysis demonstrate that the scientific method and critical thinking abilities are strongly correlated effectively children learn, depending on the gender difference. The importance of critical thinking abilities’ positive effects on learning outcomes of the female students was 81.60% and towards the learning results of the male students was 59.1. The usefulness of the science process skill in terms of practical contribution variable towards the learning results of the female students was 4.5%, and the male students were 20.6%. This means that the average simultaneous is classified as high. However, science process skills' contribution to learning results is relatively low. The research finding shows that the science process skills have a low effective contribution towards students’ learning results based on gender differences, needs to be a serious concern. That is, implementing the appropriate learning models to enhance the development of science process abilities.

Keywords: Critical thinking, Gender, Learning outcomes, Science process

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1. INTRODUCTION

In the last few decades, there have been many research reports on the correlation between critical thinking skills, science process skills, metacognitive skills, and learning results. However, the results of the research investigating the correlation between two predictor variables simultaneously, namely critical thinking skills and science process skills, towards learning results have not been revealed. The correlational study between critical thinking skills and learning results found a significant correlation between critical thinking skills and learning results based on levels of education [1], [2]. Another researches also reported a significant correlation between critical thinking skills and learning results based on different learning models [3]–[5]. Other research that uses learning results as the criterion variable was conducted [6], [7]. This research reported that metacognitive skills significantly correlated with students’ biology learning results.

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Arisoy and Aybek [8] also found that students with good critical thinking skills strongly contributed to their learning results.

Correlational research between science process skills and students’ learning results found a significant correlation between science process skills and students’ learning outcomes in science learning [9], [10]. Other research on the contribution of science process skills towards learning results was conducted [11], which indicated that science process skills had a high contribution towards students’ learning results. Academic achievement, in this case, students’ cognitive learning results, is one of the critical variables that should be taught to students because it is closely related to learning styles [12]. On the other hand, the research by Mazana, Montero, and Casmir [13] found that statistically, there was a significant correlation between students’ attitudes and their learning achievement through the implementation of specific learning models. Kamba et al. [14] found that there was a correlation between the level of students’ science process skills and their attitudes toward science learning.

In connection with the various research findings, learning results become one of the focuses of this research. Learning results are the students’ abilities after receiving a learning experience [15]. Uge, Neolaka, and Yasin [16] divided learning results into three types, namely skills and habits, knowledge, and guidance. Shuja et al. [17] also stated that independent learning is strongly related to students’ academic achievement. Akbari and Sahibzada [18] said that students with high self-confidence might make more efforts to achieve better learning results than those with low confidence and low motivation to learn.

Learning results are the impacts a person obtains after learning activities, including changes in knowledge, attitudes, and skills in the learning [19]. Learning results play an essential role in achieving the students’ future success. Lack of attention to students’ academic achievement can decrease students’ learning results [20]. Research by Tran [21] pointed out that students’ learning results can be improved by improving their motivating students. The students’ low involvement in learning is thought to be one of the factors causing the students’ common learning results [22]. Learning processes that involve cognition include receiving external stimuli by sensory, storing and processing the stimulants in the brain to become information, which can be retrieved to solve problems [23]. Learning results can be helpful feedback for teachers in implementing the learning process to determine whether or not a diagnosis, placement, or guidance for students are necessary [24].

In addition to learning results, critical thinking skills also have an essential role in ensuring quality education and students’ learning success [25]. Critical thinking is one of the crucial factors contributing to improving students’ academic achievement [26]. Critical thinking today is an educational outcome highly appreciated by the entire spectrum of education, especially in higher and professional education. Many research results have suggested the importance of designing educational strategies based on learning styles to improve students’ critical thinking skills. In addition to critical thinking skills, student learning styles are important factors that play a fundamental role in the problem-solving process in the learning [27]. Students can conduct an evaluation and observe every problem comprehensively, so they are ready to face global competition with good critical thinking skills [28]. Utami et al. [29] stated that empowering students’ critical thinking skills in every learning process is required.

An important factor that can affect the improvement of students’ learning results is students’ science process skills. Students’ science process skills can be empowered by practicing scientific problem-solving to find information independently [30]. Science process skills are essential in improving students’ thinking process in the learning [31]. Improving students’ science process skills is primarily determined by the student’s efforts to realize and understand the science and technology field’s development [31]. Science process skills play an essential role in scientists and everyone who should master these skills to solve everyday problems. Science process skills are cognitive and psychomotor skills used in issue-solving, problem identification, data collection, transformation, interpretation, and communication [32].

In this research, the indicators of integrated science process skills include: identifying variables, interpreting data, formulating hypotheses, providing operational definitions, and conducting experiments [33]. Science process skills are defined as skills that help to learn, find ways and methods to do investigations and research, increase lifelong learning, make students active, increase students’ responsibilities and understanding of practical studies, increase students’ sense of responsibility for their learning [34], [35]. Science process skills are a learning process used to solve scientific problems using scientific methods. Science process skills are tools for identifying problems, formulating hypotheses about issues, making valid predictions, identifying and defining variables, and designing experiments to test hypotheses [36].

Research on the correlation between gender differences and critical thinking skills has been widely reported. For example, research by several researchers [37]–[39] revealed that there was a significant difference in critical thinking skills between male students and female students. In addition, research on science process skills based on gender differences by Zubaidah et al. [40] found a significant difference in science process skills between female and male students at implementing different learning strategies.
Darmaji et al. [41] in the research on the contribution of critical thinking skills and science process skills based on gender reported that the critical thinking skills of female students were better than those of male students. In contrast, the science process skills of male students in learning tended to be better than those of female students [42]. Bećirović [43] found a strong correlation between students’ motivation and learning results based on gender differences in biology learning.

Based on the results of the previous research, this research aims at showing the contribution of critical thinking skills and science process skills towards students’ learning results based on gender differences in biology learning of senior high schools in Sumbawa, Indonesia. What has been updated in this research is that there have been many research results related to correlation tests related to science process skills, metacognitive skills, and other 21st-century skills variables. However, correlation research that simultaneously uses two predictor variables, namely skills critical thinking and scientific process skills on learning outcomes, has never been revealed; this has become a renewal in this research. The study’s contribution is by looking at the relationship between the two predictor variables and the measured variables.

2. RESEARCH METHOD

This correlational research investigates the multiple contributions of critical thinking and science process skills to students’ learning results based on gender differences. In this research, critical thinking and science process skills are used as the predictor variables, while learning results are used as the criterion variable. The population of this research was all students of Class X in the even semester of the academic year in biology learning. The total samples of this research were 104 students consisting of 49 male students and 55 female students. The sampling technique used is random sampling. The samples were distributed to different schools, namely Senior High School 1 Moyo Utara, Senior High School 1 Moyo Hulu, Senior High School 1 Lape, and Senior High School 1 Alas. The four schools were located in different districts and sub-districts of Sumbawa, Indonesia.

This research was carried out for six months using specific learning models. The research data were collected using an essay test of 20 question items. The essay test was administered two weeks after the posttest to obtain data about the student’s critical thinking skills, science process skills, and learning results. Zubaidah et al. [40] stated the critical thinking skills were measured by referring to the rubric developed with the indicators focus, reason, inference, clarity, and overview. The indicators of the integrated science process skills in this research included; identifying variables, interpreting data, formulating hypotheses, providing operational definitions, and conducting experiments [44].

The normality and homogeneity of the data were analyzed using Kolmogorov-Smirnov test. After that, the hypothesis testing was carried out using multiple regression analysis with a significance level of 5% to determine the contribution of critical thinking skills and science process skills towards students’ learning results based on gender differences. Before the instrument was used, it had been initially tested for its validity and reliability through empirical validation. The results of the validity and reliability test using the Cronbach alpha formula for critical thinking skills were declared valid and reliable with a significance value of (0.01) and a reliability value of (0.90). Similarly, the science process skills test was also declared valid and reliable.

The data analysis in this research uses multiple regression analysis (ANOVA) using SPSS 23.0 for Windows.

3. RESULTS

3.1. The contributions of critical thinking skills and science process skills toward the learning results of male students

The results of the ANOVA analysis in Table 1 show a significant correlation between critical thinking skills and science process skills towards the learning. The results of the analysis show that male students have an $F_{\text{crit}}=142.410$ with a significance level ($0.000$). The data in Table 2 are the regression equation between critical thinking skills and science process skills towards the learning results of male students, with the regression equation of $Y=13.566 - 0.870X_1 + 0.057X_2$. The results of the multiple regression in Table 3 show that the $(R)$ value between the critical thinking skills and science process skills toward the retention of male students is 0.928. The practical contribution value in Table 4 shows that the simultaneous contributions of critical thinking are 81.60%. While the contribution value to science process skills is 4.5% in explaining the learning outcomes of male students.
Table 1. ANOVA on the correlation between critical thinking skills and science process skills, and male students’ learning outcomes

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>3530.999</td>
<td>2</td>
<td>1765.499</td>
<td>142.410</td>
<td>.000</td>
</tr>
<tr>
<td>Residual</td>
<td>570.274</td>
<td>46</td>
<td>12.397</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4101.273</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Regression coefficient of male students

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized coefficients</th>
<th>Standardized coefficients</th>
<th>Beta</th>
<th>T</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>13.566</td>
<td>3.427</td>
<td>3.959</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>1 CriticalMan</td>
<td>.870</td>
<td>.062</td>
<td>.883</td>
<td>14.071</td>
<td>.000</td>
</tr>
<tr>
<td>ScienceMan</td>
<td>.057</td>
<td>.041</td>
<td>.087</td>
<td>1.388</td>
<td>.172</td>
</tr>
</tbody>
</table>

Table 3. Multiple regression of male students

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.928</td>
<td>.855</td>
<td></td>
<td>3.52097</td>
</tr>
</tbody>
</table>

Table 4. Contribution of critical thinking skills and science process skills to male students’ learning outcomes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Relative contribution (%)</th>
<th>Effective contribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1 (Critical thinking skills)</td>
<td>94.80</td>
<td>81.60</td>
</tr>
<tr>
<td>X2 (Science process skills)</td>
<td>5.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>86.10</td>
</tr>
</tbody>
</table>

3.2. The contribution of critical thinking and science process skills to female students’ learning results

The results of the ANOVA analysis in Table 5 show that the value of $F_{\text{count}}=102.172$ with a significance level (0.000). This means that there is a significant correlation between critical thinking skills and science process skills in the learning results of female students. The regression coefficient value in Table 6 indicates that the regression equation is $Y=15.309-0.719X_1+0.182X_2$.

Table 5. ANOVA on the correlation between critical thinking, science process skills, and female students’ learning outcomes

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2613.442</td>
<td>2</td>
<td>1306.721</td>
<td>102.172</td>
<td>.000</td>
</tr>
<tr>
<td>Residual</td>
<td>665.050</td>
<td>52</td>
<td>12.789</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3278.492</td>
<td>54</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Regression coefficient of female students

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized coefficients</th>
<th>Standardized coefficients</th>
<th>Beta</th>
<th>T</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>15.309</td>
<td>4.485</td>
<td>3.413</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>1 CriticalMan</td>
<td>.719</td>
<td>.076</td>
<td>.692</td>
<td>9.405</td>
<td>.000</td>
</tr>
<tr>
<td>ScienceMan</td>
<td>.182</td>
<td>.044</td>
<td>.306</td>
<td>4.156</td>
<td>.000</td>
</tr>
</tbody>
</table>

The results of multiple regression analysis in Table 7 show that the (R) value is 0.893. This means there is a significant correlation between critical thinking skills and science process skills toward the learning results. Table 8 shows that the simultaneous contribution of critical thinking and science process skills in explaining the learning results of the female students is 59.1%. While the science process skills of 20.6% in explaining the learning outcomes of female students.
4. DISCUSSION

The multiple regression analysis results show a significant correlation between critical thinking skills and science process skills towards students’ learning results based on gender differences in biology learning. The results of the analysis on the simultaneous contribution of the two predictor variables towards the criterion variable, in this case, critical thinking skills and science process skills towards students’ learning results indicate that the simultaneous contribution value in both male and female students in explaining students’ learning results is categorized as very high criteria. The results of the multiple regression analysis (Tables 1 and 5) show that the value of $F_{	ext{count}}$ in male students is 142.410 with a significance level (0.000). Similarly, the value of $F_{	ext{count}}$ in female students is 102.172 with a significance level of (0.000).

The results of this analysis indicate a significant correlation between critical thinking skills and science process skills towards the students’ learning results based on gender differences. This finding is in line with the research results by Muhan and Nasrudin [45], which reported that critical thinking skills had a significant correlation with student learning results. Other research findings related to the criterion variable, in this case, found that there was a significant correlation between metacognitive skills and student learning results at the implementation of certain learning models [46]–[48]. Fuad et al. [4] also reported no significant correlation between critical thinking skills and student self-efficacy in the performance of certain learning models. However, there was a significant difference between students’ critical thinking skills and learning results based on differences in education levels.

Previous research findings related to the correlation between science process skills and learning results found that there was a significant correlation between science process skills and student learning results in science learning [10], [49], [50]. Another research conducted by Kamba et al. [14] found a significant correlation between science process skills and students’ attitudes toward implementing different learning strategies. However, the research results Darmaji et al. [41] found no significant correlation between critical thinking skills and science process skills viewed based on gender differences. Achieving optimal science process skills requires a combination of high-order thinking skills, one of which is the critical thinking skills [14]. Critical thinking skills have a statistically positive predictive effect on science process skills [51]. Implementing integrated learning models can be a recommendation to improve the students’ science process skills and academic achievement [52].

The results of multiple regression analysis (Tables 2 and 6) show that the regression equation is $Y=13.566-0.870X_1+0.057X_2$ with the contribution value of 86.10% in explaining the learning results of male students. The correlation coefficient (R) value is 0.928. In addition, the results of the multiple regression analysis show that the equation is $Y=55.726-0.143X_1+0.51X_2$, with a contribution value of 79.7% in explaining the learning results of female students with a correlation coefficient value (R) of 0.893. Based on the simultaneous contribution value of each variable based on gender, it can be explained that critical thinking and science process skills have a very high contribution value toward the students’ learning results. This finding is in line with the research results Bahri and Corebima [46], reporting that learning motivation and metacognitive skills have a very high contribution value towards the students’ learning results at the implementation of different learning models. Other research conducted by Kristiani et al. [53] reported that metacognitive skills and scientific attitudes significantly contribute to students’ academic achievement. Furthermore, Adiansyah et al. [54] also stated that metacognitive skills and motivation significantly contribute to students’ retention in biology learning.

Correlational research compares students’ personality factors’ relative contribution to their academic achievements based on learning strategies. The results of the multiple regression analysis showed that the personality test has a strong effective contribution towards improving students’ learning results. Yanuarti and Rosmayanti [55] also examined the correlation between students’ motivation, independent learning, and academic achievement. Pintrich examined students’ self-efficacy, intrinsic value, anxiety tests, and self-regulation. The results of the correlation analysis showed that self-efficacy, inherent value, anxiety value, and self-regulation positively correlate with students’ learning results at the implementation of different learning

### Table 7. Multiple regression of female students

<table>
<thead>
<tr>
<th>Model summary</th>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>.893*</td>
<td>.797</td>
<td>.789</td>
<td>3.57623</td>
</tr>
</tbody>
</table>

### Table 8. Contribution of critical thinking and science process skills to female students’ learning outcomes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Relative contribution (%)</th>
<th>Effective contribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1 (Critical thinking skills)</td>
<td>74.18</td>
<td>59.1</td>
</tr>
<tr>
<td>X2 (Science process skills)</td>
<td>25.82</td>
<td>20.6</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>79.7</td>
</tr>
</tbody>
</table>

*Note:* $R$ denotes the correlation coefficient.
strategies. Panadero [56] stated that characterizing self-regulated learning as an adjustment of one’s cognitive activities and processes to the demands of certain learning situations can be continually done.

The findings of this research also indicate that critical thinking skills have a very highly effective contribution toward students’ learning results based on gender differences (Tables 4 and 8). These results follow the research results by previous researchers [57]–[59] stated that there is a difference in critical thinking skills based on gender between male and female students where the critical thinking skills of the female students are higher than those of the male students. Kumar and James [60] explained that female students have more developed argumentation skills than male students. Songsil et al. [61] stated that in the social aspect, women can deal with more complex problems than men, and women have a good level of prudence, flexible thinking, and self-confidence. Other research findings also showed no significant difference in critical thinking skills between males and females despite several research reports stating that females are superior to males in critical thinking skills [58].

The analysis results indicate that science process skills are relatively low in learning results based on gender differences. The simultaneous contribution value of science process skills in female students is higher than in male students. However, regarding critical thinking skills, it is found that the essential contribution of thinking skills toward learning results in male students is more significant than in female students. This finding is in line with the research by Ramdani et al. [62], which reported that science process skills have a significant effect on gender differences. Other research by Dahlia et al. [42] found a significant difference in science process skills between male and female students. Female students have a higher contribution value in achieving science process skills than male students [63]. Using scientific methods in scientific processes can help teachers conduct scientific work practices [64], [65]. Based on this theoretical study, it can be explained that using scientific activities in science learning can improve students’ science process skills.

Previous research findings showed the low effective contribution of science process skills towards students’ learning results are likely due to several factors, including the students’ learning motivation and attitude, which were not optimal [46]. Kristiani et al. [53] stated that the low contribution of students’ learning results is likely due to the students’ low motivation and attitudes in carrying out science learning activities. Zulirfan et al. [66] also stated that students with good science process skills will achieve better learning results. On the other hand, science process skills are defined as a learning process used to solve problems effectively using scientific methods [67]. Students who can push their learning activities properly will guarantee the continuity of their earnings and provide direction to the learning activities to achieve the learning goals [68]. Based on these theoretical facts, it can be explained that the soft science process skills in this research might be caused by internal and external factors, especially related to students’ learning motivation and attitudes during the learning process.

5. CONCLUSION

The average simultaneous relation relating critical thinking abilities to the outcomes of learning is classified as high, but the gift of science process skills towards learning results is relatively low. The research finding, which shows that the science process skills have a low effective contribution towards students’ learning results based on gender differences, needs to be a serious concern, that is implementing the appropriate learning models to enhance the acquisition of science process abilities. The analysis results on the effective each predictor variable’s contribution to the criterion variable indicate that the capacity for critical thought of male students have a higher practical contribution value towards students’ learning results than those of female students. In comparison, the science process skills of the female students have a higher practical contribution value towards the students’ learning results than those of the male students. The functional contribution value of science process skills is often poor for both male and female students.

REFERENCES


Contribution of critical thinking, science process skills towards learning outcomes


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