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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.

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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.

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 [30]. 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 in 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 toward 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 skill 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_{count}=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

ANOVA[a]						
	Model	Sum of squares	df	Mean square	F	Sig.
1	Regression	3530.999	2	1765.499	142.410	.000[b]
	Residual	570.274	46	12.397		
	Total	4101.273	48			

Table 2. Regression coefficient of male students

Coefficients[a]						
	Model	Unstandardized coefficients B	Standardized coefficients Std. Error	Beta	T	Sig.
	(Constant)	13.566	3.427		3.959	.000
1	CriticalMan	.870	.062	.883	14.071	.000
	ScienceMan	.057	.041	.087	1.388	.172

Table 3. Multiple regression of male students

Model summary				
Model	R	R Square	Adjusted R Square	Std. Error of the estimate
1	.928[a]	.861	.855	3.52097

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

Variable	Relative contribution (%)	Effective contribution (%)
X1 (Critical thinking skills)	94.80	81.60
X2 (Science process skills)	5.2	4.5
Total	100	86.10

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_{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

ANOVA[a]						
	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2613.442	2	1306.721	102.172	.000[b]
	Residual	665.050	52	12.789		
	Total	3278.492	54			

Table 6. Regression coefficient of female students

Coefficients[a]						
	Model	Unstandardized coefficients B	Standardized coefficients Std.Error	Beta	T	Sig.
	(Constant)	15.309	4.485		3.413	.001
1	CriticalMan	.719	.076	.692	9.405	.000
	ScienceMan	.182	.044	.306	4.156	.000

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.

Table 7. Multiple regression of female students

Model summary				
Model	R	R Square	Adjusted R Square	Std. Error of the estimate
1	.893[a]	.797	.789	3.57623

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

Variable	Relative contribution (%)	Effective contribution (%)
X1 (Critical thinking skills)	74.18	59.1
X2 (Science process skills)	25.82	20.6
Total	100	79.7

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_{count} in male students is 142.410 with a significance level (0.000). Similarly, the value of F_{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

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

[1] J. Siburian, A. D. Corebima, Ibrohim, and M. Saptasari, "The correlation between critical and creative thinking skills on cognitive learning results," *Eurasian Journal of Educational Research*, vol. 2019, no. 81, pp. 99–114, 2019, doi: 10.14689/ejer.2019.81.6.

[2] E. Anggraeny and S. Khongput, "Teachers' Teachers' perceptions and practices of critical thinking instruction in Indonesian senior high schools: a case study," *Teflin Journal*, vol. 33, no. 1, pp. 1–26, 2022, doi: 10.15639/teflinjournal.v33i1/1-26.

[3] A. Fitriani, S. Zubaidah, H. Susilo, and M. H. I. Al Muhdhar, "The correlation between critical thinking skills and academic achievement in biology through problem based learning-predict observe explain (PBLPOE)," *International Journal of Learning*, vol. 6, no. 3, pp. 170–176, 2020, doi: 10.18178/IJLT.6.3.170-176.

[4] N. M. Fuad, S. Zubaidah, S. Mahanal, and E. Suarsini, "Improving junior high schools' critical thinking skills based on test three different models of learning," *International Journal of Instruction*, vol. 10, no. 1, pp. 101–116, 2017, doi: 10.12973/iji.2017.1017a.

[5] Supratman, S. Zubaidah, A. D. Corebima, and Ibrohim, "The effect size of different learning on critical and creative thinking skills of biology students," *International Journal of Instruction*, vol. 14, no. 3, pp. 187–206, 2021, doi: 10.29333/iji.2021.14311a.

[6] M. Y. Afoan and A. D. Corebima, "The correlation of metacognitive skills and learning results toward students' retention of biology learning: students learning only to pass examinations," *Educational Process: International Journal*, vol. 7, no. 3, pp. 171–179, 2018, doi: 10.22521/edupij.2018.73.1.
[7] L. Naimnule and A. D. Corebima, "The correlation between metacognitive skills and critical thinking skills toward students' process skills in biology learning," *Journal of Pedagogical Research*, vol. 2, no. 2, pp. 122–134, 2018.
[8] B. Arisoy and B. Aybek, "The effects of subject-based critical thinking education in mathematics on students' critical thinking skills and virtues*," *Eurasian Journal of Educational Research*, vol. 2021, no. 92, pp. 99–120, 2021, doi: 10.14689/ejer.2021.92.6.
[9] Zainuddin *et al.*, "The correlation of scientific knowledge-science process skills and scientific creativity in creative responsibility based learning," *International Journal of Instruction*, vol. 13, no. 3, pp. 307–316, 2020, doi: 10.29333/iji.2020.13321a.
[10] E. Karademir and U. Ulucinar, "Examining the relationship between middle school students' critical reading skills, science literacy skills and attitudes: a structural equation modeling," *Journal of Education in Science, Environment and Health*, vol. 3, no. 1, pp. 29–29, 2016, doi: 10.21891/jeseh.275669.
[11] S. N. Kane, A. Mishra, and A. K. Dutta, "Preface: International Conference on Recent Trends in Physics (ICRTP 2016)," *Journal of Physics: Conference Series*, vol. 755, no. 1, 2016, doi: 10.1088/1742-6596/755/1/011001.
[12] M. J. Z. Abidin, A. A. Rezaee, H. N. Abdullah, and K. K. B. Singh, "Learning styles and overall academic achievement in a specific educational system," *International Journal of Humanities and Social Science*, vol. 1, no. 10, pp. 143–152, 2011.
[13] M. Y. Mazana, C. S. Montero, and R. O. Casmir, "Investigating students' attitude towards learning mathematics," *International Electronic Journal of Mathematics Education*, vol. 14, no. 1, pp. 207–231, 2018, doi: 10.29333/iejme/3997.
[14] A. H. Kamba, A. A. Giwa, I. A. Libata, and G. T. Wakkala, "The relationship between science process skills and student attitude toward physics in senior secondary school in Aliero metropolis," *African Educational Research Journal*, vol. 6, no. 3, pp. 107–113, 2018, doi: 10.30918/aerj.63.18.038.
[15] Sulasih, A. Suparmi, and Sarwanto, "Profile of student critical thinking ability on static fluid concept," *Journal of Physics: Conference Series*, vol. 909, no. 1, 2017, doi: 10.1088/1742-6596/909/1/012060.
[16] S. Uge, A. Neolaka, and M. Yasin, "Development of social studies learning model based on local wisdom in improving students' knowledge and social attitude," *International Journal of Instruction*, vol. 12, no. 3, pp. 375–388, 2019, doi: 10.29333/iji.2019.12323a.
[17] A. Shuja, I. A. Qureshi, D. M. Schaeffer, and M. Zareen, "Effect of m-learning on students' academic performance mediated by facilitation discourse and flexibility," *Knowledge Management and E-Learning*, vol. 11, no. 2, pp. 158–200, 2019, doi: 10.34105/j.kmel.2019.11.009.
[18] O. Akbari and J. Sahibzada, "Students' self-confidence and its impacts on their learning process," *American International Journal of Social Science Research*, vol. 5, no. 1, pp. 1–15, 2020, doi: 10.46281/aijssr.v5i1.462.
[19] Y. Yusnaeni, A. D. Corebima, H. Susilo, and S. Zubaidah, "Creative thinking of low academic student undergoing search solve create and share learning integrated with metacognitive strategy," *International Journal of Instruction*, vol. 10, no. 2, pp. 245–262, 2017, doi: 10.12973/iji.2017.10216a.
[20] R. Nazempour, H. Darabi, and P. C. Nelson, "Impacts on students' academic performance due to emergency transition to remote teaching during the COVID-19 pandemic: A financial engineering course case study," *Education Sciences*, vol. 12, no. 3, pp. 1–14, 2022, doi: 10.3390/educsci12030202.
[21] V. D. Tran, "Does cooperative learning increase students' motivation in learning?" *International Journal of Higher Education*, vol. 8, no. 5, pp. 12–20, 2019, doi: 10.5430/ijhe.v8n5p12.
[22] G. Maheshwari, "Factors affecting students' intentions to undertake online learning: an empirical study in Vietnam," *Education and Information Technologies*, vol. 26, no. 6, pp. 6629–6649, 2021, doi: 10.1007/s10639-021-10465-8.
[23] O. E. Backsanskij and E. A. Dergacheva, "Cognitive processes of the brain and learning theory," *Proceedings of the International Scientific Conference "Far East Con" (ISCFEC 2020)*, 2020, vol. 128, pp. 66–70, doi: 10.2991/aebmr.k.200312.010.
[24] A. S. Munna and M. A. Kalam, "Teaching and learning process to enhance teaching effectiveness: literature review," *International Journal of Humanities and Innovation (IJHI)*, vol. 4, no. 1, pp. 1–4, 2021, doi: 10.33750/ijhi.v4i1.102.
[25] P. J. A. C. van der Zanden, E. Denessen, A. H. N. Cillessen, and P. C. Meijer, "Fostering critical thinking skills in secondary education to prepare students for university: teacher perceptions and practices," *Research in Post-Compulsory Education*, vol. 25, no. 4, pp. 394–419, 2020, doi: 10.1080/13596748.2020.1846313.
[26] R. Nur'azizah, B. Utami, and B. Hastuti, "The relationship between critical thinking skills and students learning motivation with students' learning achievement about buffer solution in eleventh grade science program," *Journal of Physics: Conference Series*, vol. 1842, no. 1, pp. 1–9, 2021, doi: 10.1088/1742-6596/1842/1/012038.
[27] F. Shirazi and S. Heidari, "The relationship between critical thinking skills and learning styles and academic achievement of nursing students," *Journal of Nursing Research*, vol. 27, no. 4, pp. 1–7, 2019, doi: 10.1097/jnr.0000000000000307.
[28] A. Halim, Ngadimin, Soewarno, Sabaruddin, and A. Susanna, "Improvement of high order thinking skill of physics student to prepare human resources in order to faced of global competition in ASEAN economic community," *Journal of Physics: Conference Series*, vol. 1116, no. 3, pp. 1–7, 2018, doi: 10.1088/1742-6596/1116/3/032009.
[29] B. Utami, R. M. Probosari, S. Saputro, Ashadi, and M. Masykuri, "Empowering critical thinking skills with problem solving in higher education," *Journal of Physics: Conference Series*, vol. 1280, no. 3, 2019, doi: 10.1088/1742-6596/1280/3/032047.
[30] I. Damopolii, V. T. Botutihe, and J. H. Nunaki, "The contribution of science process skill towards students cognitive achievement through guided inquiry-based learning," *Journal of Physics: Conference Series*, vol. 1317, no. 1, pp. 1–6, 2019, doi: 10.1088/1742-6596/1317/1/012184.
[31] A. Sideri and M. Skoumios, "Science process skills in the Greek primary school science textbooks," *Science Education International*, vol. 32, no. 3, pp. 231–236, 2021, doi: 10.33828/sei.v32.i3.6.
[32] V. Sönmez, "Association of cognitive, affective, psychomotor and intuitive domains in education, Sönmez model," *Universal Journal of Educational Research*, vol. 5, no. 3, pp. 347–356, 2017, doi: 10.13189/ujer.2017.050307.
[33] S. Oktavia and U. P. Dewi, "Description of integrated science process skills in physics education students in convex mirror practicum," *Formatif: Jurnal Ilmiah Pendidikan MIPA*, vol. 10, no. 2, pp. 103–114, 2020, doi: 10.30998/formatif.v10i2.5036.
[34] Suryanti, W. Widodo, and W. Budijastuti, "Guided discovery problem-posing: An attempt to improve science process skills in elementary school," *International Journal of Instruction*, vol. 13, no. 3, pp. 75–88, 2020, doi: 10.29333/iji.2020.1336a.
[35] J. O. Manes, A. Calimlim, and E. Nalupa-Farin, "Acquisition of science process skills of junior high school students among private schools of Olongapo city," *East African Scholars Journal of Education, Humanities and Literature*, vol. 5, no. 6, pp. 146–159, 2022, doi: 10.36349/easjehl.2022.v05i06.002.
[36] B. K. Temiz, "Assessing skills of identifying variables and formulating hypotheses using scenario-based multiple-choice questions," *International Journal of Assessment Tools in Education*, vol. 7, no. 1, pp. 1–15, 2020, doi: 10.21449/ijate.561895.

[37] S. Marni, M. Aliman, S. Suyono, R. Roekhan, and T. Harsiati, "Students' critical thinking skills based on gender and knowledge group," *Journal of Turkish Science Education*, vol. 17, no. 4, pp. 544–560, 2020, doi: 10.36681/tused.2020.44.
[38] Mawaddah, A. Ahmad, and M. Duskri, "Gender differences of mathematical critical thinking skills of secondary school students," *Journal of Physics: Conference Series*, vol. 1088, 2018, doi: 10.1088/1742-6596/1088/1/012054.
[39] I. Shubina and A. Kulakli, "Critical thinking, creativity and gender differences for knowledge generation in education," *Literacy Information and Computer Education Journal*, vol. 10, no. 1, pp. 3086–3093, 2019, doi: 10.20533/licej.2040.2589.2019.0405.
[40] S. Zubaidah, A. D. Corebima, S. Mahanal, and Mistianah, "Revealing the relationship between reading interest and critical thinking skills through remap GI and remap jigsaw," *International Journal of Instruction*, vol. 11, no. 2, pp. 41–56, 2018, doi: 10.12973/iji.2018.1124a.
[41] D. Darmaji, A. Astalini, D. A. Kurniawan, and W. A. Putri, "Science process skills and critical thinking ability assessed from students' gender," *Jurnal Pendidikan Fisika Indonesia*, vol. 18, no. 1, pp. 83–95, 2022, doi: 10.15294/jpfi.v18i1.30534.
[42] I. Dahlia Yuliskurniawati, N. Ika Noviyanti, W. Rosyadah Mukti, S. Mahanal, and S. Zubaidah, "Science process skills based on genders of high school students," *Journal of Physics: Conference Series*, vol. 1241, no. 1, 2019, doi: 10.1088/1742-6596/1241/1/012055.
[43] S. Bećirović, "The relationship between gender, motivation and achievement in learning English as a foreign language," *European Journal of Contemporary Education*, vol. 6, no. 2, pp. 210–220, 2017, doi: 10.13187/ejced.2017.2.210.
[44] M. B. Panjaitan and A. Siagian, "The effectiveness of inquiry based learning model to improve science process skills and scientific creativity of junior high school students," *Journal of Education and e-Learning Research*, vol. 7, no. 4, pp. 380–386, 2020, doi: 10.20448/journal.509.2020.74.380.386.
[45] L. A. Muhan and H. Nasrudin, "The correlation analysis between critical thinking skills and learning outcomes through implementation of guided inquiry learning models," *Jurnal Pendidikan Sains (JPS)*, vol. 9, no. 1, pp. 33–41, 2021, doi: 10.26714/jps.9.1.2021.33-41.
[46] A. Bahri and A. D. Corebima, "The contribution of learning motivation and metacognitive skill on cognitive learning outcome of students within different learning strategies," *Journal of Baltic Science Education*, vol. 14, no. 4, pp. 487–500, 2015, doi: 10.33225/jbse/15.14.487.
[47] L. T. Antika, "The relationship between metacognition skills with the student's achievement: the implementation of reading-concept Map-Think Pair Share (Remap TPS) model," *Jurnal Pena Sains*, vol. 5, no. 1, p. 19, 2018, doi: 10.21107/jps.v5i1.3629.
[48] Winarti, S. E. Ambaryani, and H. Putranta, "Improving learners' metacognitive skills with self-regulated learning based problem-solving," *International Journal of Instruction*, vol. 15, no. 2, pp. 139–154, 2022, doi: 10.29333/iji.2022.1528a.
[49] S. Ilma, M. H. I. Al-Muhdhar, F. Rohman, and M. Saptasari, "The correlation between science process skills and biology cognitive learning outcome of senior high school students," *JPBI (Jurnal Pendidikan Biologi Indonesia)*, vol. 6, no. 1, pp. 55–64, 2020, doi: 10.22219/jpbi.v6i1.10794.
[50] S. Samputri, "Science process skills and cognitive learning outcomes through discovery learning models," *European Journal of Education*, vol. 6, no. 12, pp. 181–189, 2020, doi: 10.5281/zenodo.3678615.
[51] Darmaji, D. A. Kurniawan, Astalini, R. Perdana, Kuswanto, and M. Ikhlas, "Do a science process skills affect on critical thinking in science? Differences in urban and rural," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 9, no. 4, pp. 874–880, 2020, doi: 10.11591/ijere.v9i4.20687.
[52] F. Prafitasari, S. Sukarno, and M. Muzzazinah, "Integration of critical thinking skills in science learning using blended learning system," *International Journal of Elementary Education*, vol. 5, no. 2, p. 434, 2021, doi: 10.23887/ijee.v5i3.35788.
[53] N. Kristiani, H. Susilo, F. Rohman, and D. C. Aloysius, "The contribution of students' metacognitive skills and scientific attitude towards their academic achievements in biology learning implementing Thinking Empowerment by Questioning (TEQ) learning integrated with inquiry learning (TEQI)," *International Journal of Educational Policy Research and Review*, vol. 2, no. 9, pp. 113–120, 2015, doi: 10.15739/IJEPRR.020.
[54] R. Adiansyah, A. M. Amin, A. Ardianto, and A. Yani, "Metacognitive skill profile of biology education students at institute of teachers' education in South Sulawesi, Indonesia," *JPBI (Jurnal Pendidikan Biologi Indonesia)*, vol. 8, no. 2, pp. 150–158, 2022, doi: 10.22219/jpbi.v8i2.20732.
[55] H. Yanuarti and D. Rosmayanti, "The relationship between students' motivation and their learning achievement," *PROJECT (Professional Journal of English Education)*, vol. 1, no. 6, p. 783, 2019, doi: 10.22460/project.v1i6.p783-788.
[56] E. Panadero, "A review of self-regulated learning: Six models and four directions for research," *Frontiers in Psychology*, vol. 8, pp. 1–28, 2017, doi: 10.3389/fpsyg.2017.00422.
[57] D. E. Sari, I. Hindun, N. Mahmudati, F. J. Miharja, and A. Fauzi, "Are male and female students different in high-order thinking skills?" *JPI (Jurnal Pendidikan Indonesia)*, vol. 9, no. 1, p. 42, 2020, doi: 10.23887/jpi-undiksha.v9i1.17575.
[58] R. Perdana, Budiyono, Sajidan, and Sukarmin, "Analysis of Student critical and creative thinking (CCT) skills on chemistry: a study of gender differences," *Journal of Educational and Social Research*, vol. 9, no. 4, pp. 43–52, 2019, doi: 10.2478/jesr-2019-0053.
[59] S. P. Kawuryan, S. A. Sayuti, and Aman, "Critical thinking among fourth grade elementary school students: A gender perspective," *Cakrawala Pendidikan*, vol. 41, no. 1, pp. 211–224, 2022, doi: 10.21831/cp.v41i1.44322.
[60] R. Kumar.R and R. James, "Evaluation of critical thinking in higher education in Oman," *International Journal of Higher Education*, vol. 4, no. 3, pp. 33–43, 2015, doi: 10.5430/ijhe.v4n3p33.
[61] W. Songsil, P. Pongsophon, B. Boonsoong, and A. Clarke, "Developing scientific argumentation strategies using revised argument-driven inquiry (rADI) in science classrooms in Thailand," *Asia-Pacific Science Education*, vol. 5, no. 1, pp. 1–22, 2019, doi: 10.1186/s41029-019-0035-x.
[62] A. Ramdani, A. W. Jufri, Gunawan, M. Fahrurrozi, and M. Yustiqvar, "Analysis of students' critical thinking skills in terms of gender using science teaching materials based on the 5e learning cycle integrated with local wisdom," *Jurnal Pendidikan IPA Indonesia*, vol. 10, no. 2, pp. 187–199, 2021, doi: 10.15294/jpii.v10i2.29956.
[63] D. Darmaji, A. Astalini, D. A. Kurniawan, and E. F. S. Rini, "Gender analysis in measurement materials: Critical thinking ability and science processing skills," *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, vol. 11, no. 1, pp. 113–128, 2022, doi: 10.24042/jipfalbiruni.v11i1.11509.
[64] Supeno, S. Astutik, and A. D. Lesmono, "Pre-service science teachers' understanding of scientific method for studying local environmental issues," *IOP Conference Series: Earth and Environmental Science*, vol. 485, no. 1, 2020, doi: 10.1088/1755-1315/485/1/012033.
[65] N. Indrilla, "The effectiveness of scientific approach and contextual teaching and learning approach in teaching writing," *Lingua Cultura*, vol. 12, no. 4, p. 405, 2018, doi: 10.21512/lc.v12i4.4452.

[66] Z. Zulirfan, M. Rahmad, Y. Yennita, N. Kurnia, and M. S. Hadi, "Science Process Skills and Attitudes toward Science of Lower Secondary Students of Merbau Island: A Preliminary Study on The Development of Maritimebased Contextual Science Learning Media," *Journal of Educational Sciences*, vol. 2, no. 2, p. 90, 2018, doi: 10.31258/jes.2.2.p.90-99.
[67] S. Yamtinah, M. Masykuri, M. Ashadi, and A. Shidiq, "An Analysis of Students' Science Process Skills in Hydrolysis Subject Matter Using Testlet Instrument," *Proceedings of the International Conference on Teacher Training and Education 2017 (ICTTE 2017)*, 2017, vol. 158, pp. 101–110, doi: 10.2991/ictte-17.2017.36.
[68] L. Darling-Hammond, L. Flook, C. Cook-Harvey, B. Barron, and D. Osher, "Implications for educational practice of the science of learning and development," *Applied Developmental Science*, vol. 24, no. 2, pp. 97–140, 2020, doi: 10.1080/10888691.2018.1537791.

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