Bioscientist: Jurnal Ilmiah Biologi
E-ISSN 2654-4571; P-ISSN 2338-5006
Vol. 10, No. 2, December 2022; Page, 1008-1017
https://e-journal.undikma.ac.id/index.php/bioscientist

MEASURING THE LEVEL OF SCIENTIFIC REASONING ABILITY OF BIOLOGY PROSPECTIVE TEACHERS

Laras Firdaus[1], Masiah[2]*, Ibrohim[3], dan Sri Rahayu Lestari[4]
[1&2]Department of Biology Education, FSTT, Mandalika University of Education, Indonesia
[3&4]Department of Biology Education, FMIPA, State University of Malang, Indonesia
**E-Mail : masiah@undikma.ac.id*
DOI : https://doi.org/10.33394/bioscientist.v10i2.6043
Submit: 19-09-2022; Revised: 17-10-2022; Accepted: 07-11-2022; Published: 30-12-2022

ABSTRACT: This research is quantitative survey research that aims to identify the level of scientific reasoning ability of Biology prospective teachers, as well as to determine the effect of the semester on scientific reasoning abilities. A total of 80 Biology prospective teachers were involved in this study, consisting of 18 (semester 2), 29 (semester 4), and 33 (semester 6). LCSTR is an instrument used to measure scientific reasoning ability. The data were analyzed descriptively to classify the level of scientific reasoning ability, while to determine the effect of the semester on scientific reasoning ability, it was analyzed univariately using SPSS 22 at a significance level of 5%. The results of this study indicate that the scientific reasoning ability of Biology prospective teachers is dominated by concrete and transitional reasoning, and semesters have no effect on scientific reasoning abilities. These results also indicate that Biology prospective teachers have the same level of scientific reasoning ability. Furthermore, these results can be concluded that the scientific reasoning ability of Biology prospective teacher students has a low level, which is at the initial level (concrete reasoning). Then for the further work, it is described a little at the conclusion of this article.

Keywords: Sientific Reasoning Ablity, LCTSR, Biology Prospective Teacher.

INTRODUCTION

Scientific reasoning is a very important ability in 21st century education (Göhner & Krell, 2022; Zhou *et al.*, 2016) or education in the 21st century emphasizes the ability of scientific reasoning to students because scientific reasoning is a very important factor that can help students to obtain good academic performance (Hrouzková & Richterek, 2021). Therefore, some educators make a consensus to emphasize the need for scientific reasoning abilities for students, not only to understand scientific concepts but also to be able to actively participate in life to achieve a more democratic life (Alshamali & Daher, 2016; Kalinowski & Willoughby, 2019). Science refers to the body of knowledge acquired through a series of processes, such as collecting data, hypothesizing, and evaluating principles or theories from new data (Masnick & Morris, 2022). Thus, scientific reasoning is defined as the search for knowledge and coordination between theory and evidence (Mayer *et al.*, 2014; Schlatter *et al.*, 2021), or scientific reasoning is synonymous with experimentation (Choowong & Worapun, 2021), and or cycle of inquiry, students who have good

Dikelola oleh : Program Studi Pendidikan Biologi
Fakultas Sains, Teknik, dan Terapan
Universitas Pendidikan Mandalika

experimental or inquiry skills will acquire knowledge quickly *(van der Graaf et al.*, 2015).

Scientific reasoning related to cognitive development (Nyberg *et al.*, 2020), includes the ability to think abstractly and logical reasoning, as well as draw conclusions based on the type of formal operational reasoning (Ha *et al.*, 2021). According to Lazonder and Janssen (2021), scientific reasoning refers to the cognitive processes involved in planning, implementing, and evaluating the results of investigations. While Morris *et al.* (2012) stated that scientific reasoning includes the reasoning and problem solving skills involved in generating, testing and revising hypotheses or theories, and in the case of fully developed skills, reflects the process of knowledge acquisition and conceptual change from investigating activities, and even recently, Kind and Osborne proposed six models of scientific reasoning, including mathematical deduction, experimental evaluation, categorizing and classifying, hypothetical models, probability reasoning, and the development of reasoning based on history (Göhner & Krell, 2022). Based on this, scientific reasoning not only plays a role in the acquisition of knowledge (Ahmad *et al.*, 2020; Alshamali & Daher, 2016; Mayer *et al.*, 2014), but also plays a role in making decisions in everyday life through a series of scientific processes, such as collecting data, evaluating arguments, and testing the hypotheses (Pelamonia *et al.*, 2017).

According to Piaget, the development of scientific reasoning abilities starts from concrete reasoning to formal reasoning (Hotulainen & Telivuo, 2014; Khan & Rana, 2021). Concrete reasoning is the reasoning that is used when dealing with concrete problems, and formal reasoning is reasoning used in various forms of problems, while transitional reasoning is a transition of reasoning from concrete reasoning to formal reasoning (Etzler & Madden, 2014). In science, we know the terms basic and integration skills. The basic skills are called concrete reasoning, including observing, making inferences, using numbers, taking measurements, classifying, communicating, and making predictions, while the integrated skills are called formal reasoning, include controlling variables, formulating hypotheses, operationally defining, interpreting, and experimentation (Woolley *et al.*, 2018).

Scientific reasoning is identic with experimentation, so its measurement is related to processes related to experimentation. Therefore, Lawson developed instruments to diagnose scientific reasoning abilities (Hrouzková & Richterek, 2021), including the ability to control variables, correlational reasoning, combination reasoning, proportional reasoning, and probabilistic reasoning (Ha *et al.*, 2021). While according to Opitz *et al.* (2017) scientific reasoning consists of eight ability as contribute to scientific reasoning, such as defining problems, formulating questions and hypotheses, gathering and evaluating evidence, and explaining and communicating results. In another study, the components in the measurement of scientific reasoning include experimenting, predicting, evaluating data, interpreting, and drawing conclusions (Lazonder & Janssen, 2021). Then in relation to learning outcomes, scientific reasoning as a construct or predictor of learning outcomes (Abate *et al.*, 2020; Jensen *et al.*, 2017; Mayer *et al.*, 2014), several studies on scientific reasoning as shown by Farillon (2022) that scientific reasoning has a positive impact on learning success. Likewise Pelamonia *et al.* (2017), show that scientific reasoning ability is correlated with increased student learning outcomes, Biology class outcomes (Piraksa *et al.*, 2014), and performance of Biology graduate students (Jensen *et al.*, 2017).

Although many studies on scientific reasoning have been carried out, it can be said that it is not evenly distributed in various countries. Abate *et al.* (2020), that the failure of science education to meet the needs of the 21st century. However, that is to some extent attributed to its inability to incorporate scientific reasoning as a good model in school teaching. Then Pelamonia *et al.* (2017) that research on scientific reasoning is very rarely carried out in Indonesia. In addition, a fact shown by Bernard & Różycki (2019) is that teachers who teach in various European countries (such as Poland) do not have good scientific reasoning abilities. In the end, the students he taught were not involved in active participation, including in scientific reasoning. The Mandalika University of Education as a school of thought has revised the curriculum to suit the demands of the 21st century, but unfortunately, students' scientific reasoning abilities have not been clearly identified because studies on students' scientific reasoning abilities are rarely carried out. In other words, there is not enough evidence about the study of scientific reasoning at the Mandalika University of Education. In an effort to improve and develop professional competence, it is necessary for Biology prospective teachers to have scientific reasoning abilities (Göhner & Krell, 2022), especially at the Mandalika University of Education, not only to gain scientific knowledgebut also as an ability that can be used to solve problems in everyday life.

In addition, when they become real teachers, they can help or train their students to build knowledge as scientists do. For this purpose, this research is considered necessary to be carried out as a stepping stone for the development of the learning process and further research (especially at the Mandalika University of Education). We know that scientific reasoning develops from an early age (Lazonder & Janssen, 2021), this indicates that scientific reasoning is influenced by age or level of education, but this has to be proven. The purpose of this study is to identify the level of scientific reasoning ability of Biology prospective teachers, and are there differences in the scientific reasoning abilities of Biology prospective teachers based on semesters?

METHOD

This research is quantitative survey research. A total of 80 Biology prospective teachers were involved in this study, consisting of 18 (2nd semester), 29 (4th semester), and 33 (6th semester). There are several instruments can be used to measure scientific reasoning abilities, such as Yenilmez *et al.* (2006), used The Test of Logical Thinking (TOLT), but the most widely used instrument was the instrument developed by Lawson (Lawson Classroom Test of Scientific Reasoning/LCTSR) (Kalinowski & Willoughby, 2019). Therefore, in this study,

Bioscientist: Jurnal Ilmiah Biologi
E-ISSN 2654-4571; P-ISSN 2338-5006
Vol. 10, No. 2, December 2022; Page, 1008-1017
https://e-journal.undikma.ac.id/index.php/bioscientist

LCTSR is an instrument used to measure the scientific reasoning ability of prospective Biology teacher students.

The data obtained were then analyzed descriptively to determine the level of scientific reasoning of the Biology prospective teacher (including concrete reasoning, transitional reasoning, and formal reasoning). Lawson compiled a score to classify scientific reasoning abilities, 0-5 (concrete reasoning), 6-11 (transitional reasoning), and >11 (formal reasoning) (Bao *et al.*, 2018). Then to find out whether the academic level (in this case is semester) has an influence or not on scientific reasoning abilities, the data were analyzed using analysis of variance (ANOVA) with SPSS 22 at the 5% significance level.

RESULTS AND DISCUSSIONS

This research was conducted at the Mandalika University of Education on a Biology prospective teachers. Based on the results of the descriptive analysis as shown in Tables 1 and 2. Table 1 shows the mean and standard deviation of the scientific reasoning ability scores of Biology prospective teachers by semester, while Table 2 shows the percentage level of scientific reasoning ability of Biology prospective teachers.Table 3 shows the results of the prerequisite test analysis (homogeneity test using Levene's test), it is stated that the data is homogeneous. Then Table 4 shows the results of the analysis of variance of scientific reasoning abilities, and Table 5 shows the results of the post hoc analysis on the mean difference scores of scientific reasoning abilities.

Table 1. Mean of Scientific Reasoning Ablity by Semesters.

Semesters	*N*	Mean	Std. Deviation
2nd semester	18	4.94	1.92
4th semester	30	6.43	3.15
6th semester	33	6.55	2.85
Total	80		

Table 2. Percentage of Scientific Reasoning Ability by Semesters.

Semesters	Concrete rasoning	Transitional reasoning	Formal reasoning
2nd semester	0.83	0.17	0.00
4th semester	0.40	0.47	0.13
6th semester	0.36	0.55	0.09
Total	1.59	1.19	0.22

From Tables 4 and 5, it is stated that the semester does no effect on Biology prospective teachersscientific reasoning ability. This indicates that Biology prospective teachershave relatively the same level of scientific reasoning abilities. Meanwhile, if we look back at the information in Table 2, the scientific reasoning ability of Biology prospective teachers is dominated by concrete and transitional types of reasoning. This indicates that concrete and transitional reasoning is the reasoning used to solve problems (Etzler & Madden, 2014). Scientific reasoning is an ability that is very difficult for students to college student, and about 50% of students have difficulty when dealing with scientific reasoning (Woolley *et al.*, 2018). In accordance with the findings of Ahmad *et al.* (2020), there is no difference in scientific reasoning ability between students in

Dikelola oleh : Program Studi Pendidikan Biologi
Fakultas Sains, Teknik, dan Terapan
Universitas Pendidikan Mandalika

Bioscientist: Jurnal Ilmiah Biologi
E-ISSN 2654-4571; P-ISSN 2338-5006
Vol. 10, No. 2, December 2022; Page, 1008-1017
https://e-journal.undikma.ac.id/index.php/bioscientist

public schools and students in private schools. While Ding *et al.* (2016), showed that students' scientific reasoning abilities did not have a significant difference from the first year to the fourth year.

Table 3. Levene Test Result.

Levene Statistic	df1	df2	Sig.
3.710	2	78	.069

Table 4. Analysis of Variance Test Result.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33.729	2	16.865	2.155	.123
Within Groups	610.493	78	7.827		
Total	644.222	80			

Table 5. Post Hoc Analysis.

(I) Semester	(J) Semester	Mean Difference (I-J)	Std. Error	Sig.
2nd semester	4th semester	-1.49	.834	.181
	6th semester	-1.60	.820	.131
4th semester	2nd semester	1.49	.834	.181
	6th semester	-.11	.706	.986
6th semester	2nd semester	1.60	.820	.131
	4th semester	.11	.706	.986

These results indicate the scientific reasoning ability of Biology prospective teachers at the low level, or the initial level of reasoning. Prospective teacherswho usually uses concrete reasoning have difficult to learn scientific concepts (Hrouzková & Richterek, 2021). We really hope that the 6th semester teacher candidates have better scientific reasoning abilities than the 2nd and 4th semesters of Biology prospective teachers. Considering these results, it is appropriate to ask questions about the factors that cause the academic level (in this case the semester) to have no effect on scientific reasoning abilities.

In our opinion, perhaps the low level of scientific reasoning ability of Biology prospective teachers is caused by personal factors and the learning environmentor socio-cultural (Morris *et al.*, 2012). Personal factors in this case refer to self-knowledge (self-confidence) (Guo *et al.*, 2022), relate to curiosity-which is curiosity that motivates a person to seek information that leads to goals (Jirout, 2020), and at the same time activating prior knowledge to construct scientific arguments or reasoning (Jirout, 2020). In addition, epistemological beliefs are personal factors that also influence the ability of scientific reasoning. Epistemological beliefs refer to one's beliefs about knowing and the nature of knowledge (Ongowo, 2021), construct scientific arguments and reasoning (Klopp & Stark, 2022). Epistemological beliefs have a gradation from the lowest to the highest (from naive to sophisticated) (Hotulainen & Telivuo, 2014). So, it can simply be understood that Biology prospective teachers who has high epistemological beliefs can have better scientific reasoning abilities than those who have low epistemological beliefs. In line with this, several research findings also show a positive relationship between epistemological beliefs and cognitive processes, such as argumentation and scientific reasoning abilities, and reflective thinking (Guo *et al.*, 2022).

Bioscientist: Jurnal Ilmiah Biologi
E-ISSN 2654-4571; P-ISSN 2338-5006
Vol. 10, No. 2, December 2022; Page, 1008-1017
https://e-journal.undikma.ac.id/index.php/bioscientist

Although the learning environment does not manifest itself as the only factor that affects the level of scientific reasoning ability (Ding, 2018) but at least the learning environment or socio-cultural is a factor directly related to scientific reasoning ability (Bezci & Sungur, 2021; Boğar, 2019). The learning environment and/or socio-cultural refers to the method or learning model used by the lecture in the teaching and learning process (Talib *et al.*, 2018). The learning model used by lecturers when teaching does not facilitated Biology prospective teachers to reasoning (Tajudin & Chinnappan, 2017), does not facilitated prospective teachers to use scientific skills, such as planning investigations, collecting data, and communicating experimental results (Kambeyo, 2017). In the views of constructivism, the lecture must act as facilitators rather than as sources of knowledge, learning must be designed with an emphasis on the active involvement of prospective teacher in scientific research activities (Bao & Koenig, 2019). Referring to the opinion of van der Graaf *et al.* (2015), regarding scientific reasoning which is identical to the inquiry cycle, the inquiry learning model is one of the learning models that can be used by lecture to improve the scientific reasoning abilities of Biology prospective teacher (Bezci & Sungur, 2021; Ding, 2018; Wu *et al.*, 2016). Through inquiry-based learning, students and teachers can find a causal relationship between phenomena by formulating hypotheses and testing them, both through observation and experimentation, and ultimately has an impact on increasing scientific reasoning abilities (Pedaste *et al.*, 2015).

CONCLUSION

Based on the results of the analysis and the limitations of the discussion, it can be concluded that the scientific reasoning ability of Biology prospective teacher at the Mandalika University of Education has a low level (concrete and transitional reasoning), and the semester has no significant effect on scientific reasoning abilities. The results of this study cannot be generalized because it was only carried out at the Mandalika University of Education ona Biology prospective teachers, perhaps the results would be different if measurements were taken at other universities. For us, scientific reasoningabilities are something that can be improved. Concrete reasoning is the basic reasoning used by students to obtain formal reasoning (Khan & Rana, 2021).

In the process of guidingto Biology prospective teachers to obtain good scientific reasoning abilities, the learning process can start from concrete problems and then move on to abstract problems. In the pedagogical aspect, learning designed by lectures must provide opportunities for Biology prospective teachers to use scientific skills, such as collecting information, hypothesizing, conducting experiments, analyzing, interpreting and drawing conclusions, and communicating experimental results. The learning model that covers all these scientific skills is the inquiry learning model. Thus, the inquiry learning model is recommended to be used to improve scientific reasoning abilities.In addition, the lecture can also develop teaching materials based on scientific reasoning as an integral part of to improve the scientific reasoning abilities of Biology prospective teachers.

Dikelola oleh : Program Studi Pendidikan Biologi
Fakultas Sains, Teknik, dan Terapan
Universitas Pendidikan Mandalika

RECOMMENDATIONS

This study only focuses on measuring the level of scientific reasoning ability of Biology prospective teachers. From the previous description, it is known that scientific reasoning ability is influenced by several factors, such as curiosity and epistemological beliefs. Considering that studies on epistemological beliefs are rarely carried out in Indonesia (including at the Mandalika University of Education). Therefore, further research can examine the relationship between epistemological beliefs and scientific reasoning abilities.

ACKNOWLEDGEMENTS

Thanks to the Ministry of Education and Culture, Research and Technology to provide financial support for completing this research through decree No. 0969/LL8/AK.04/2022.

REFERENCES

Abate, T., Michael, K., and Angell, C. (2020). Assessment of Scientific Reasoning: Development and Validation of Scientific Reasoning Assessment Tool. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(12), 1-15.

Ahmad, M., Shah, A.H., and Raheem, A. (2020). Scientific Reasoning Ability and Academic Achievement of Secondary School Students. *Global Regional Review*, *5*(I), 356-363.

Alshamali, M.A., and Daher, W.M. (2016). Scientific Reasoning and its Relationship with Problem Solving: The Case of Upper Primary Science Teachers. *International Journal of Science and Mathematics Education*, *14*(6), 1003-1019.

Bao, L., and Koenig, K. (2019). Physics Education Research for 21st Century Learning. *Disciplinary and Interdisciplinary Science Education Research*, *1*(2), 1-12.

Bao, L., Xiao, Y., Koenig, K., and Han, J. (2018). Validity Evaluation of the Lawson Classroom Test of Scientific Reasoning. *Physical Review Physics Education Research*, *14*(2), 1-19.

Bernard, P., and Różycki, K.D. (2019). Influence of Training in Inquiry-Based Methods on In-Service Science Teachers' Reasoning Skills. *Chemistry Teacher International*, *1*(2), 1-12.

Bezci, F., and Sungur, S. (2021). How is Middle School Students' Scientific Reasoning Ability Associated with Gender and Learning Environment? *Science Education International*, *32*(2), 96-106.

Boğar, Y. (2019). Evaluation of the Scientific Reasoning Skills of 7th Grade Students in Science Course. *Universal Journal of Educational Research*, *7*(6), 1430-1441.

Choowong, K., and Worapun, W. (2021). The Development of Scientific Reasoning Ability on Concept of Light and Image of Grade 9 Students by Using Inquiry-Based Learning 5E with Prediction Observation and Explanation Strategy. *Journal of Education and Learning*, *10*(5), 152-159.

Ding, L. (2018). Progression Trend of Scientific Reasoning from Elementary School to University: A Large-Scale Cross-Grade Survey among Chinese Students. *International Journal of Science and Mathematics Education*, *16*(1), 1479-1498.

Ding, L., Wei, X., and Mollohan, K. (2016). Does Higher Education Improve Student Scientific Reasoning Skills? *International Journal of Science and Mathematics Education*, *14*(4), 619-634.

Etzler, F.M., and Madden, M. (2014). The Test of Logical Thinking as a Predictor of First-Year Pharmacy Students' Performance in Required First-Year Courses. *American Journal of Pharmaceutical Education*, *78*(6), 1-4.

Farillon, L.M.F. (2022). Scientific Reasoning, Critical Thinking, and Academic Performance in Science of Selected Filipino Senior High School Students. *Utamax: Journal of Ultimate Research and Trends in Education*, *4*(1), 51-63.

Göhner, M., and Krell, M. (2022). Preservice Science Teachers' Strategies in Scientific Reasoning: The Case of Modeling. *Research in Science Education*, *52*(2), 395-414.

Guo, X., Hao, X., Deng, W., Ji, X., Xiang, S., and Hu, W. (2022). The Relationship Between Epistemological Beliefs, Reflective Thinking, and Science Identity: A Structural Equation Modeling Analysis. *International Journal of STEM Education*, *9*(1), 1-17.

Ha, M., Sya'bandari, Y., Rusmana, A.N., Aini, R.Q., dan Fadillah, S.M. (2021). Comprehensive Analysis of the Fort Instrument: Using Distractor Analysis to Explore Students' Scientific Reasoning Based on Academic Level and Gender Difference. *Journal of Baltic Science Education*, *20*(6), 906-923.

Hotulainen, R., and Telivuo, J. (2014). *Epistemological Beliefs and Scientific Reasoning in Finnish Academic Upper Secondary Education*. *Kasvatus & Aika*, 9(1), 92-106.

Hrouzková, T., and Richterek, L. (2021). Lawson Classroom Test of Scientific Reasoning at Entrance University Level. In *Proceedings of the 4th International Baltic Symposium on Science and Technology Education* (*BalticSTE2021*) (pp. 74-85). Šiauliai, Lithuania: Vilnius University.

Jensen, J.L., Neeley, S., Hatch, J.B., and Piorczynski, T. (2017). Learning Scientific Reasoning Skills may be Key to Retention in Science, Technology, Engineering, and Mathematics. *Journal of College Student Retention: Research, Theory & Practice*, *19*(2), 126-144.

Jirout, J.J. (2020). Supporting Early Scientific Thinking Through Curiosity. *Frontiers in Psychology*, *11*(1), 1-7.

Kalinowski, S.T., and Willoughby, S. (2019). Development and Validation of a Scientific (Formal) Reasoning Test for College Students. *Journal of Research in Science Teaching*, *56*(9), 1269-1284.

Kambeyo, L. (2017). Scientific Reasoning Skills: A Theoretical Background on Science Education. *NERA Journal*, *14*(1), 40-64.

Khan, K.A., and Rana, R.A. (2021). Effect of Higher Order Thinking Instructional Model on Scientific Reasoning of Grade VIII Students. *Bulletin of Education and Research*, *43*(1), 77-92.

Klopp, E., and Stark, R. (2022). Scientific Controversies and Epistemological Sensitization-Effects of an Intervention on Psychology Students' Epistemological Beliefs and Argumentation Skills. *Frontiers in Education*, *6*(1), 1-20.

Lazonder, A.W., and Janssen, N. (2021). Development and Initial Validation of a Performance-Based Scientific Reasoning Test for Children. *Studies in Educational Evaluation*, *68*(1), 1-20.

Masnick, A.M., and Morris, B.J. (2022). A Model of Scientific Data Reasoning. *Education Sciences*, *12*(1), 1-19.

Mayer, D., Sodian, B., Koerber, S., and Schwippert, K. (2014). Scientific Reasoning in Elementary School Children: Assessment and Relations with Cognitive Abilities. *Learning and Instruction*, *29*(1), 43-55.

Morris, B.J., Croker, S., Masnick, A.M., and Zimmerman, C. (2012). The Emergence of Scientific Reasoning. In *Current Topics in Children's Learning and Cognition* (pp. 61-82). Rijeka, Croatia: Janeza Trdine.

Nyberg, K., Koerber, S., and Osterhaus, C. (2020). How to Measure Scientific Reasoning in Primary School: A Comparison of Different Test Modalities. *European Journal of Science and Mathematics Education*, *8*(3), 136-144.

Ongowo, R.O. (2021). Students' Epistemological Beliefs from Grade Level Perspective and Relationship with Science Achievement in Kenya. *Education Inquiry*, *13*(3), 287-303.

Opitz, A., Heene, M., and Fischer, F. (2017). Measuring Scientific Reasoning–a Review of Test Instruments. *Educational Research and Evaluation*, *23*(3), 78-101.

Pedaste, M., Mäeots, M., Siiman, L.A., de Jong, T., van Riesen, S.A.N., Kamp, E. T., Manoli, C.C., Zacharia, Z.C., and Tsourlidaki, E. (2015). Phases of Inquiry-Based Learning: Definitions and the Inquiry Cycle. *Educational Research Review*, 14(1), 47-61.

Pelamonia, J., Mahananingtyas, E., dan Johannes, N.Y. (2017). Empowerment Scientific Reasoning in Science Learning for Junior High School Students in Ambon City. *Proceeding International Seminar on Education*, *1*(1), 104-113.

Piraksa, C., Srisawasdi, N., and Koul, R. (2014). Effect of Gender on Student's Scientific Reasoning Ability: A Case Study in Thailand. *Procedia - Social and Behavioral Sciences*, *116*(1), 486-491.

Schlatter, E., Lazonder, A.W., Molenaar, I., and Janssen, N. (2021). Individual Differences in Children's Scientific Reasoning. *Education Sciences*, *11*(9), 1-13.

Tajudin, N.M., and Chinnappan, M. (2017). Relationship between Scientific Reasoning Skills and Mathematics Achievement among Malaysian Students. *International Journal of Contemporary Applied Researches*, *4*(12), 40-64.

Talib, C.A., Rajan, S.T., Hakim, N.W.A., Malik, A.M.A., Siang, K.H., and Ali, M. (2018). Gender Difference as a Factor in Fostering Scientific Reasoning Skill Among Students. In *International Conference on Engineering Education (ICEED)* (pp. 54-58). Kuala Lumpur, Malaysia: University Teknologi MARA.

van der Graaf, J., Segers, E., and Verhoeven, L. (2015). Scientific Reasoning Abilities in Kindergarten: Dynamic Assessment of the Control of Variables Strategy. *Instructional Science*, *43*(3), 381-400.

Woolley, J.S., Deal, A.M., Green, J., Hathenbruck, F., Kurtz, S.A., Park, T.K.H., Pollock, S.V., Transtrum, M.B., and Jensen, J.L. (2018). Undergraduate Students Demonstrate Common False Scientific Reasoning Strategies. *Thinking Skills and Creativity*, *27*(1), 101-113.

Wu, H.L., Weng, H.L., and She, H.C. (2016). Effects of Scaffolds and Scientific Reasoning Ability on Web-Based Scientific Inquiry. *International Journal of Contemporary Educational Research*, *3*(1), 12-24.

Yenilmez, A., Sungur, S., and Tekkaya, C. (2006). Students' Achievement in Relation to Reasoning Ability, Prior Knowledge and Gender. *Research in Science & Technological Education*, *24*(1), 129-138.

Zhou, S., Han, J., Koenig, K., Raplinger, A., Pi, Y., Li, D., Xiao, H., Fu, Z., and Bao, L. (2016). Assessment of Scientific Reasoning: The Effects of Task Context, Data, and Design on Student Reasoning in Control of Variables. *Thinking Skills and Creativity*, *19*(1), 175-187.