Journal of Natural Science and Integration
P-ISSN: 2620-4967|E-ISSN: 2620-5092
Vol. 6, No. 1, April 2023, pp 28-38

Available online at:
http://ejournal.uin-suska.ac.id/index.php/JNSI
DOI: 10.24014/jnsi.v6i1.22007

Integration of Argumentation Activities in Virtual-Inquiry to Improve Argumentation Skills of Prospective Science Teachers in Basic Physics Courses

Siswanto[1*], Bambang Subali[2], & Ellianawati[2]

[1] *Department of Science Education, Universitas Tidar, Indonesia*
[2] *Department of Physics Education, Universitas Negeri Semarang, Indonesia*

*Correspondence Author: *siswanto@untidar.ac.id*

ABSTRACT
Argumentation skills are a prominent domain that must be trained for prospective science teacher students. This study aims to determine the effectiveness of science learning which is implemented using virtual inquiry learning in improving the argumentation skills of prospective science teachers. We used a quasi-experimental method with a non-equivalent control class design where researchers divided students into two classes: the experimental class (N = 38) and the control class (N = 38). The learning process in the experiment class was carried out by the virtual-inquiry model which was inserted with scientific argumentation activities, while in the control class, the learning process was carried out using the virtual-inquiry model without inserting scientific argumentation activities. All students involved in the research were given a test to measure argumentation skills between before and after the learning process. Argumentation skills are analyzed in two aspects, namely the completeness of organs and the scientific aspect. Data were analyzed by categorizing each student's answer into each aspect of argumentation skills, both before and after the learning process. After that, the mean difference significance test was carried out. Then, n-gain was used to analyze the increase of argumentation skill. The results indicate that the virtual-inquiry model which was inserted by argumentation activities was better at improving the argumentation skills of prospective science teachers compared to the virtual inquiry model without being inserted by argumentation activities. In the experimental class, the increase in argumentation skills showed high criteria. These results were obtained both on the aspect of organ completeness and the scientific aspect. Meanwhile, in the control class, it is in the low category for the aspect of organ completeness and is in the moderate category for the scientific aspect. These findings indicate that in scientific argumentation training, it is very important to involve students to practice argumentation directly.

Keywords: *virtual-inquiry, argumentation skill, scientific aspect of argumentation, organ completeness aspect of argumentation*

INTRODUCTION

It has been acknowledged that virtual learning process (in network/online/blended learning) is prominent (Garrison, 2020) as well as in science learning. Virtual learning is urgent to do now because it makes access easier (Musingafi, 2015). According to Biao (2012), the learning process that is carried out virtually/online has several benefits, namely that it can be accessed openly, and is not hindered by time and distance. The importance of virtual learning contrasts with the realization on the ground. Based on research results, learning that is done virtually is less effective in increasing mastery of higher-order thinking skills (Musingafi, 2015; Arinto, 2016; Vidergor, 2015). In fact, the existence of this is essential to facilitate pupils to master thinking skills such as higher-order thinking skills (Zohar, 2003; Duraippah, 2021). Because, by mastering high order thinking skills (HOTs), students are trained to deal with contextual problems (Saido, 2018; Heong, 2012).The existence of HOTs is prominent for students to master the argumentation skills. According to Osborne (2004), ideally students could master argumentation skills through trainings of it in the science classroom. This is because the thinking skill became foundation to build an explanation, models, and studied theories in specific domain of science (Zohar, 2002). Therefore, in the virtual learning process, aspects of argumentation skills need to be emphasized so that students can be trained.

In addition, as a prospective science teachers, students must master the concept as a whole as a provision to teach their students in the future. Through the facilitation of training in argumentation skills in the learning process, students are also directly trained to fully master natural science concepts at the higher-order thinking level. The results indicate that practicing argumentation skills in could drive students easily construct and master the concept as a whole (Siswanto, 2019; Siswanto, 2018; Yusiran, 2016; Siswanto, 2014; Sampson, 2010; Erduran, 2008). Argumentation skills relate to the process of strengthening a claim through critical thinking analysis based on support with evidence and logical reasons. This evidence may contain objective facts or conditions that can be accepted as truth (Kuhn, 2010). According to Toulmin (2003), arguments resemble an organism that has individual parts with different functions whose indicators include claims (sentences proposed to others to be accepted as truth or desired actions to be performed), data (truth underlying a claim), warrants (sentences explaining the association between claims and the submitted), backing (additional expressions supporting justification of all theories or facts that explain justification). Argumentation activities integrated into learning as a provision for argumentation skills are based on Toulmin's argumentation framework (Lazarou, 2021).

Problems arise in the process of virtual instruction because the learning activities are conducted without face-to-face meetings in front of the class (done online). This makes the teacher unable to exercise direct control to organize students in learning, thus reducing the meaning of the instructional process. Moreover, the process of science learning emphasizes process and outcomes as the representation of the nature of science (Rennie, 2003; Dwianto, 2017). of course, this will influence learning outcomes being an optimal outcome (in this case, mastery of concepts). Some research shows that the virtual learning process has a negative impact on student academic performance (Bird, 2022; Dumford, 2018). Therefore, to make science learning meaningful in the virtual learning process, it is necessary to have a learning innovation. Virtual learning innovations that are carried out must still prioritize the nature of science as a process and product.

One type of learning that emphasizes the nature of science is inquiry learning (El Khalik, 2004; White, 1998). Based on research results, inquiry learning can build mastery of concepts in higher-order thinking dimensions (Wenning, 2011). In addition, inquiry activities positioned students being as scientists (Harlen, 2014). The difficulty for science educators is how to optimize inquiry learning in the virtual science learning process (Siswanto, 2020). This is because so far most of the practice of inquiry learning has been done offline (face-to-face in class) (Khalaf, 2018; Andrini, 2016). The research aimed to analyze the effectiveness of science learning which was conducted by using virtual-inquiry learning in improving the argumentation skills of science teacher candidates. Most of the research related to argumentation in inquiry activities is done offline, while this research will be done online. In practice, argumentation activities will be integrated into online virtual inquiry learning. Through the integration of argumentation activities, it is hoped that it will provide more optimal results in improving the argumentation skills of prospective science teacher candidates.

METHODOLOGY

This research used a quasi-experimental method, specifically a design of non-equivalent control group. Then, the groups are divided into an experimental and a control class. The treatment of virtual inquiry integrating argument mode was implemented in the experimental class while a control class was intervened by enacting virtual-inquiry mode only. Prior to the process in the classroom, a pretest was conducted in both classes to obtain initial data on argumentation skills. Then after the learning process, in both classes, a posttest was carried out to get the final data about argumentation skills.

This research involved 76 science teacher candidates at a public university in Central Java. All students were divided into two classes: an experimental and a control class, which each group was 38 students. The sample selection was carried out using a purposive sampling technique, with the condition that all students involved in this course had never taken this course before and had not been trained in argumentation skills. The students involved in this research were students who were taking basic physics courses. All students participated in this research activity.

This study used an essay test to examine the argumentation skills of prospective science teacher candidates. The test used consists of one question (see Figure 1). To guarantee the reliability of the categories used, an inter-coder reliability test was used, in which the researcher took a 20% sample of student answers that had been categorized for analysis by two experts in Science Education who had researched scientific arguments (Cetin, 2014). In the inter-coder reliability test, a kappa score of 0.76 was obtained with strong criteria.

Pay attention to the following statements!

"It is impossible for an object whose velocity is 0 but whose acceleration is not 0"

Do you agree with this statement? Explain!

Figure 1. Instrument test

In general, the argumentation skills examined in this study refer to the framework proposed by Toulmin (2003) which includes claims, data, warrants, and backing. In this study, argumentation skills were analyzed in two aspects, namely the scientific domain and the completeness of the argumentation organ which was compiled by adopting research conducted by Cetin (2014). The scoring criteria for each aspect of argumentation skills (see Table 1 and Table 2).

Table 1. Scoring criteria for organ completeness aspects

Level Achievement	Description	Score
Level 1	Only claim	0
Level 2	Compile claims and data	1
Level 3	Compile claims, data, and warrant	2
Level 4	Compile claims, data, warrant, and backing	3

Table 2. Scoring criteria for scientific aspects

Category	Description	Score
T1	Scientific with complete concept	3
T2	Scientific with incomplete concept	2
S1	Scientific but concept no relationship	1
S2	Scientific, but wrong concept	1
NE	Does not explain the answer	0

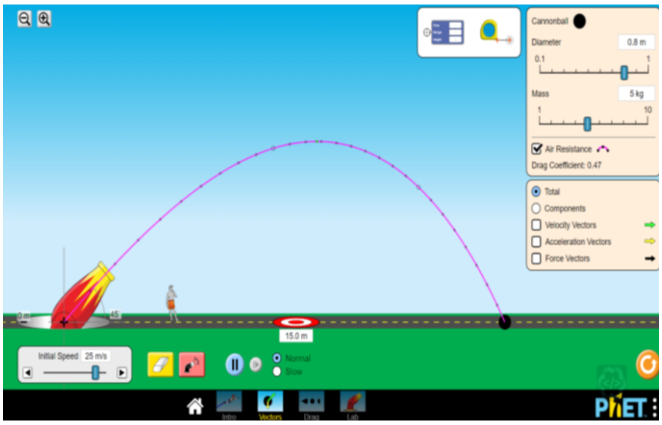
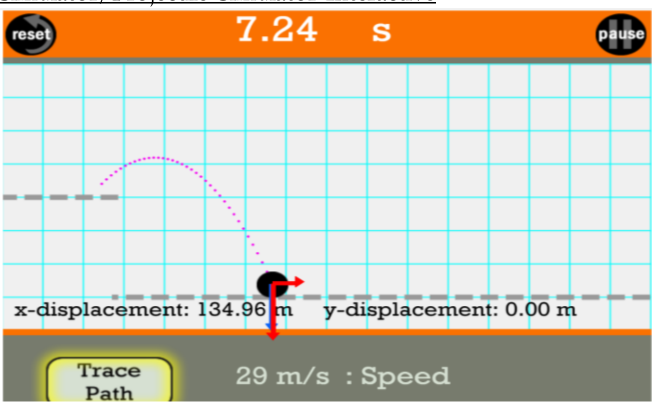
Once scoring completed, the average difference test was carried out between the experimental and the control class. These averages were conducted between: (1) experimental and control class pretest data, (2) experimental and control class posttest data, and (3) pretest and posttest data on experimental and control class. Furthermore, the overall normalized gain test was carried out for both scientific aspects and organ completeness to analyze the increase in argumentation skills in the experimental and control class using the equation (1) formulated by Hake (1999).

$$< Ngain > = \frac{(Posttest - Pretest)}{(Maximum\ score - Pretest)} \quad (1)$$

Then, the N-gain score (g) is categorized according to the following criteria: low ($g < 3$), medium ($3 \leq g \leq 7$), and high ($g > 7$). In the final stage, the percentage of category achievements for each aspect was calculated in both the experimental and control class.

In this study, the learning process carried out in the experimental class used a virtual-inquiry learning scheme that was integrated with argumentation activities. Meanwhile, the control class used a virtual-inquiry instructional scheme without being integrated with argumentation activities. Learning is carried out to investigate problems on the topic of parabolic motion. In both classes, the same problems were raised to be investigated by students (Table 3), where the investigation process used a virtual laboratory.

Table 3. Problems Investigated

The Problems		Link of Virtual Laboratory
I	Analyzing the effect of elevation angle on the height and range of objects fired at the ground level ($h_0 = 0$)	https://phet.colorado.edu/sims/html/projectile-motion/latest/projectile-motion_en.html 
II	Analyzing the effect of the initial angle on the range of objects fired at a certain height ($h_0 = h$)	https://www.physicsclassroom.com/Physics-Interactives/Vectors-and-Projectiles/Projectile-Simulator/Projectile-Simulator-Interactive 

The learning activities carried out in the experimental and the control class (see Table 4). The main difference is that in the experimental class, students are directly trained to practice the preparation of arguments, whereas in the control class this is not done. The argumentation practice training carried out by students is guided by using worksheets.

Table 4. Learning activities in the experimental and control class

Experimental Class		Control Class	
Learning Stages	**Student Activities**	**Learning Stages**	**Student Activities**
Identify the problem	Do a literature study and analyze the problem	*Identify the problem*	Do a literature study and analyze the problem
Formulate hypotheses using argumentation activities	Formulate hypotheses in the form of claims accompanied by provision of evidence, justification, and provisional support	*Formulate hypotheses*	Formulate hypotheses
Conduct investigations to test hypotheses based on argumentation activities	Conduct hypothesis testing using a virtual laboratory application based on student worksheets provided by lecturers	*Conduct investigations to test hypotheses*	Conduct hypothesis testing using a virtual laboratory application based on student worksheets provided by lecturers
Performing data analysis using student worksheet guides	Perform data analysis and evaluation of hypotheses based on student worksheets	*Performing data analysis using student worksheet guides*	Perform data analysis and evaluation of hypotheses based on student worksheets
Communicating the results	Conduct discussions by presenting the results of worksheets that have been filled in and revised according to the lecturer's input using the framework of argumentation activities	*Communicating the results*	Conduct discussions by presenting the results of worksheets that have been filled in and revised according to the lecturer's input

RESULT AND DISCUSSION

There was no significant difference in the average argumentation skill between the pretest of the experimental and control class, both for the aspect of organ completeness ($p = 0.155 \geq 0.05$, the mean rank of the experimental class = 41.33, the mean rank of the control class = 35 .69) as well as the scientific aspect of argumentation ($p = 0.944 \geq 0.05$, the mean rank of the experimental class = 38.04, the mean rank of the control class = 38.96). This indicates that the average initial argumentation skills of students in the two classes are not significantly different. Meanwhile, there was a significant average difference between the posttest of the experimental and control class, both for the aspect of organ completeness ($p = 0.000 < 0.05$, the mean rank of the experimental class = 52.99, the mean rank control class = 24.01) and scientific aspects of argumentation ($p = 0.005 < 0.05$, mean rank of experimental class = 45.32, mean rank of control class = 31.68). These results indicated that the treatment given to the experimental class had a better impact than the control class.

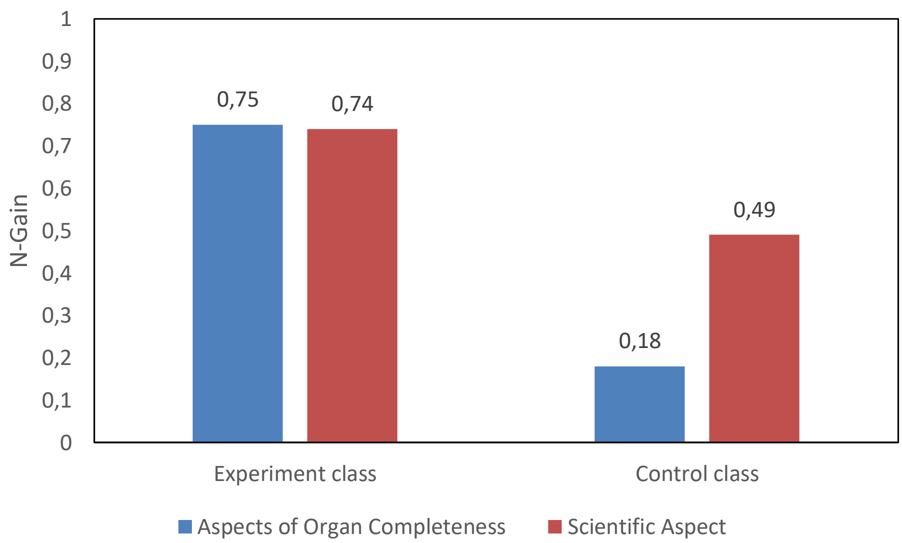


Figure 2. Test results for increasing argumentation skills in both classes

Furthermore, the improvement test (n-gain test) of argumentation skills was carried out as a benchmark for the effectiveness of the treatment given. The improvement of argumentation skills in the experimental class is better than in the control class. For both aspects (organ completeness and scientific aspect), the increase of the experimental class is in the high category, while in the control class, it is in the low category for the aspect of organ completeness and is in the moderate category for the scientific aspect.

The test results for improving argumentation skills, both aspects of the organ completeness and the scientific aspect, can be seen in Figure 2. In more detail, Table 5 and Table 6 describe the differences in the achievement of argumentation skills, before and after learning in experimental and control classes. Table 5 presents data related to the achievement of the arguments for the aspect of organ completeness and Table 6 presents data related to the achievements of the arguments for the scientific aspects of the arguments prepared. In general, both for the aspect (the organ completeness and the scientific aspect), the achievement of argumentation skills in the experimental class after the treatment was better than the control class.

As seen in Table 5 (the control class), there were students who were at level 1, level 2 (most were at this level), and level 3 before learning. After the learning process, levels 1 and level 2 decreased (even 0 for levels 1), while level 3 and level 4 increased, although slightly. It is mean that there is an increase in the achievement of organ completeness after the learning process.

After learning in the control class, more students reach level 2 (65.8%), namely compiling arguments by submitting claims and data, and level 3 (28.9%), namely compiling arguments by submitting claims, data, justification, and support. Only a few students were able to reach level 4 (5.3%), namely compiling arguments with complete organs (claims, data, justification, and support).

In contrast to the experimental class, before the learning process, there were students who were at level 1, level 2 (most were at this level), level 3, and level 4. After the learning process, levels 1 and level 2 decreased (even 0 for level 1), while level 3 and level 4 increased. The most increase was at level 4. That is, there was an increase in the achievement of organ completeness after the learning in the experimental class. The biggest increase was at level 4. After the learning, more students reached level 4 (60.5%) and level 3 (34.2%).

Table 5. Achievement of organ completeness aspect argumentation skills before and after learning

	Control Class		Experiment Class	
	Pretest (%)	Posttest (%)	Pretest (%)	Posttest (%)
Level 1	7,9	0	7,9	0
Level 2	78,9	65,8	63,2	5,3
Level 3	13,2	28,9	26,3	34,2
Level 4	0	5,3	2,6	60,5

Table 6. Achievement of scientific aspect argumentation skills before and after learning

	Control Class		Experiment Class	
	Pretest (%)	Posttest (%)	Pretest (%)	Posttest (%)
T1	0	26,3	0	63.2
T2	5,3	44,7	2.6	21.1
S1	34,2	7,9	23.7	2.6
S2	52,6	21,1	65.8	13.2
NE	7,9	0	7.9	0

In Table 6, before the learning process in the control class, there were students who were in the NE, S2, S1, and T2 categories. The majority are in the S2 category (52.6%) and S1 (34.2%). After the learning process, the NE, S2, and S1 categories experienced a reduction, and the T1 and T2 categories experienced additions. The biggest addition was in the T2 category of 44.7%. It is mean that there is an increase in the achievement of the scientific aspect of the control class.

Even though there was an increase in achievement in the scientific aspect in the control class, the increase in achievement showed better results in the experimental class. Prior to the learning process, there were students in the S2, S1, and T2 categories. The majority are in the S2 category (65.8%) and S1 (23.7%). After the learning process, the S2 and S1 categories experienced a reduction, and the T1 and T2 categories experienced additions. The biggest addition was in the T1 category of 63.2%. It is mean that there is an increase in the achievement of the scientific aspect of argumentation skills after the learning process. The resulting improvement was better than the control class.

Based on these findings, in the control class, virtual-inquiry learning activities were able to improve argumentation skills from the scientific aspect in the moderate category. This is because the scientific aspect is influenced by the mastery factor of the material content. The increase in argumentation skills on the scientific aspect (medium category) in virtual-inquiry learning (control class) is proof that these learning activities are able to build mastery of the content of the material being studied. According to Harlen (2014), the process of inquiry is not just transferring knowledge, but training the students to develop the knowledge by a scientific process. This causes the learning process that is built to be more meaningful.

The research findings show that learning that is carried out using the process of inquiry has several advantages, including being able to construct the student knowledge from a low to a high level of cognition (Harlen, 2014; Wenning, 2011). In addition, the scientific process built in inquiry is able to practice the intellectual skills which play a role in developing mastery of material content (Kai Wu, 2006).

In contrast to the scientific aspect, virtual-inquiry learning that was built in the control class was not effective in improving the skills of reasoning in the aspect of organ completeness (low improvement category). This is because virtual-inquiry learning does not directly train students to construct scientific argumentation. In fact, to train argumentation skills from the construction aspect of the organs, direct training is needed for students to build argumentation organs (Cetin, 2014; Venville, 2010).

In the experimental class, both aspects (aspects of organ completeness and scientific aspects) experienced an increase in the high category. The number of achievement skills in arguing aspects of organ completeness that was better in the experimental class than in the control class occurred because the learning process carried out involved direct practice of argumentation skills. In the learning activities carried out, the inquiry stage is inserted with argumentation activities. The learning process is carried out by providing two problems as shown in Table 3 (two topics). According to Cetin (2014), involving the practice of scientific argumentation directly in the learning process can increase the complexity of arguments prepared by students in a relatively short period of time. These results are also consistent with the findings of Zohar (2002) and Venville (2010), who found that there was a significant increase in the complexity aspect of the arguments compiled after a relatively short treatment.

Apart from the practice of constructing arguments in the learning process, the number of skills achieved in arguing aspects of organ completeness was better in the individual experimental class than the control class because the mastery of the concepts formed in the individual experimental class was better than the control class. Several studies claim that mastery of concepts is positively correlated with the quality and quantity of arguments prepared (Clark, 2008; Glassner, 2005). The better achievement of the scientific aspect in the experimental class compared to the control class was due to the better mastery of the concepts formed in the experimental class than the control class. Scientific argumentation activities embedded in virtual-inquiry learning in the experimental class were able to make students' mastery of concepts better. Better mastery of concepts makes students more skilled in compiling arguments from scientific aspects. Research results show that mastery of concepts is positively correlated with the achievement of argumentation skills (Siswanto, 2019; Siswanto, 2018; Yusiran, 2016; Siswanto, 2014; Sampson, 2010).

The research findings are proof that argumentation skills training can be done online with good results. Therefore, it can be an example in the preparation of online learning activities that train argumentation skills in learning science. In this study, it is limited to basic physics lectures, so it does not rule out the possibility of conducting other research in other lectures.

CONCLUSION

Based on the results, it can be concluded that the argumentation activities embedded in virtual-inquiry learning was better at improving the argumentation skills of prospective science teachers compared to the virtual inquiry model without being inserted by argumentation activities, both in terms of organ completeness and scientific aspects. In the experiment class, the aspect of completeness of the organs, there was an increase of 0.75 in the high category and the scientific aspect, there was an increase of 0.74 in the high category. In the control class, the aspect of completeness of the organs, there was an increase of 0.18 in the low category and the scientific aspect, there was an increase of 0.49 in the moderate category. The research findings show that after conducting virtual inquiry learning which is interleaved with argumentation activities, the highest achievement of argumentation skills for science teacher candidates is at level 4 and the scientific category with a complete concept. These results indicate that it is very important to involve prospective teacher students to practice argumentation directly in the learning process.

REFERENCES

Andrini, V. S. (2016). The Effectiveness of Inquiry Learning Method to Enhance Students' Learning Outcome: A Theoritical and Empirical Review. *Journal of Education and Practice*, *7*(3), 38-42.

Arinto, P. B. (2016). Issues and Challenges in Open and Distance e-learning: Perspectives from the Philippines. *The International Review of Research in Open and Distributed Learning*, 17(2).

Biao, I. (2012). Open and Distance Learning: Achievements and Challenges in a Developing Sub-Educational Sector in Africa. In Distance Education. Intech.

Bird, K. A., Castleman, B. L., & Lohner, G. (2022). Negative Impacts from The Shift to Online Learning During The Covid-19 Crisis: Evidence from a Statewide Community College System. *Aera Open*, *8*, 23328584221081220.

Cetin, P. S. (2014). Explicit argumentation instruction to facilitate conceptual understanding and argumentation skills. *Research in Science & Technological Education*, *32*(1), 1-20.

Clark, D. B., & V. Sampson. 2008. Assessing Dialogic Argumentation in Online Environments to Relate Structure, Grounds, and Conceptual Quality. *Journal of Research in Science Teaching*. 45(3), 293–321.

Dumford, A. D., & Miller, A. L. (2018). Online Learning in Higher Education: Exploring Advantages and Disadvantages for Engagement. *Journal of computing in higher education*, *30*, 452-465.

Duraippah, K., Hamidon, Z. B., & Ong, P. (2021). Using Instructional Materials to Develop Higher Order Thinking Skills. *ASEAN Journal of Open & Distance Learning (AJODL)*, *13*(2), 83-96.

Dwianto, A., Wilujeng, I., Prasetyo, Z. K., & Suryadarma, I. G. (2017). The Development of Science Domain Based Learning Tool Which is Integrated with Local Wisdom to Improve Science Process Skill and Scientific Attitude. *Jurnal Pendidikan IPA Indonesia*, *6*(1).

El Khalick, A., F., Boujaoude, S., Duschl, R., Lederman, N. G., Mamlok-Naaman, R., Hofstein, A., & Tuan, H. L. (2004). Inquiry in Science Education: International Perspectives. *Science Education*, *88*(3), 397-419.

Erduran, S., & Maria, P. (2008). *Argumentation in Science Education*. London: Spinger Science.

Garrison, R. (2000). Theoretical Challenges for Distance Education in The 21st Century: A Shift from Structural to Transactional Issues. *The International Review Of Research In Open And Distributed Learning,* 1(1).

Glassner, A., Weinstock, M., & Neuman, Y. (2005). Pupils' Evaluation And Generation Of Evidence and Explanation in Argumentation. *British Journal of Educational Psychology*. 75(1), 105-118..

Hake, R.R. (1999). Interactive-engagement vs Traditional Methods: A Six Thousand Student Survey of Mechanic Test Data for Introductory Physics Courses. *Journal of Physics*. 66 (1): 64-74.

Harlen, W. (2014). Helping Children's Development of Inkuiri Skills. *Inkuiri in Primary Science Education*, 1(1) 5-19.

Heong, Y. M., Yunos, J. M., Othman, W., Hassan, R., Kiong, T. T., & Mohamad, M. M. (2012). The Needs Analysis of Learning Higher Order Thinking Skills for Generating Ideas. *Procedia-Social and Behavioral Sciences,* 59, 197-203.

Kai Wu, H. (2006). Developing Sixth Graders' Inkuiri Skills to Construct Explanations in Inkuiri-based Learning Environments. *International Journal of Science Education*, 28 (11): 1289-1313.

Khalaf, B. K., & Mohammed Zin, Z. B. (2018). Traditional and Inquiry-Based Learning Pedagogy: a Systematic Critical Review. *International Journal of Instruction*, *11*(4), 545-564.

Lazarou, D., & Erduran, S. (2021). "Evaluate What I Was Taught, Not What You Expected Me to Know": Evaluating Students' Arguments Based on Science Teachers' Adaptations to Toulmin's Argument Pattern. *Journal of Science Teacher Education, 32*(3), 306-324.

Kuhn. (2010). *Teaching and Learning Science as Argument.* Wiley Periodicals, Inc. Sci Ed, v (94), 810-824,

Musingafi, M. C., Mapuranga, B., Chiwanza, K., & Zebron, S. (2015). Challenges for Open and Distance Learning (ODL) Students: Experiences from Students of the Zimbabwe Open University. *Journal of Education and Practice*, 6(18), 59-66.

Osborne, J., Erduran, S. & Simon, S. (2004). Enhancing The Quality of Argumentation in School Science. *Journal of Research in Science Teaching*. 41 (10), 994-1020.

Rennie, L. J., Feher, E., Dierking, L. D., & Falk, J. H. (2003). Toward an Agenda for Advancing Research on Science Learning in Out-of-School Settings. *Journal of Research in Science Teaching*, *40*(2), 112-120.

Saido, G. M., Siraj, S., Nordin, A. B. B., & Al_Amedy, O. S. (2018). Higher Order Thinking Skills Among Secondary School Students in Science Learning. *MOJES: Malaysian Online Journal of Educational Sciences, 3*(3), 13-20.

Sampson, V., & Gerbino, F. (2010). Two Instructional Models That Teacher Can Use to Promote & Support Scientific Argumentation In the Biology Classroom. *The American Biology Teacher,* 72 (7), 427-431.

Siswanto, S., Hartono, H., Subali, B., & Masturi, M. (2022). Infusing Explicit Argumentation in Science Reading Activities: Helping Prospective Science Teachers Reduce Misconception and Foster Argumentation Skills. *Pegem Journal of Education and Instruction*, *12*(3), 177-189.

Siswanto, S., Trisnowati, E., Firmadani, F., Haryati, S., Aryanti, D., & Andrianto, H. N. (2020). Workshop on Inquiry Learning Based Virtual Laboratory in Magelang for Preparing Natural Sciences Teacher in 21st Century: An Evaluation Of Implementation's Program. *Indonesian Journal of Education and Learning*, *3*(2), 367-373.

Siswanto, S., Yusiran, Y., Gumilar, S., H. Hartono, Subali, B., Muhlisin, A., Juliyanto, E., & Trisnowati, E. (2019). Enhancing Students' Cognitive Ability by Implanting Argumentation Activity on Inquiry Lab. *Journal of Physics: Conference Series* 1280 (5), 052003.

Siswanto, S., Yusiran, Y., Asriadin, A., Gumilar, S., & Subali, B. (2018). Scientific Method by Argumentation Design: Learning Process for Maintaining Student's Retention. *JPhCS*, *983* (1), 012021.

Siswanto. (2014). Penerapan Model Pembelajaran Pembangkit Argumen Menggunakan Metode Saintifik untuk Meningkatkan Kemampuan Kognitif dan Keterampilan Berargumentasi Siswa. *Jurnal Pendidikan Fisika Indonesia,* 10 (2): 104-116.

Toulmin, S. E. (2003). The Uses of Argument. *Cambridge University Press.*

Venville, G. J., & Dawson, V. M. (2010). The Impact of a Classroom Intervention on Grade 10 Students' Argumentation Skills, Informal Reasoning, and Conceptual Understanding of Science. *Journal of Research in Science Teaching*, *47*(8), 952-977.

Vidergor, H. E. (2018). Effectiveness of The Multidimensional Curriculum Model in Developing Higher-Order Thinking Skills in Elementary and Secondary Students. *The Curriculum Journal*, 29(1), 95-115.

Wenning, C., J. (2011). Experimental Inkuiri in Introductory Physics Courses. *Journal of Physics Teacher Education, 6* (2), 2-8.

White, B. Y., & Frederiksen, J. R. (1998). Inquiry, Modeling, and Metacognition: Making Science Accessible to All Students. *Cognition and instruction*, *16*(1), 3-118.

Yusiran, Y., & Siswanto, S. (2016). Implementasi Metode Saintifik Menggunakan Setting Argumentasi pada Mata Kuliah Mekanika untuk Meningkatkan Kemampuan Kognitif Mahasiswa Calon Guru Fisika. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *2*(1), 15-22.

Zohar, A., & Dori, Y. J. (2003). Higher Order Thinking Skills and Low-Achieving Students: are They Mutually Exclusive?. *The journal of the learning sciences*, *12*(2), 145-181.

Zohar, A., & Nemet, F. (2002). Fostering Students Knowledge and Argumentation Skills Through Dilemmas In Human Genetics. *Journal of Research in Science Teaching, 39 (1), 35-62.*