JURNAL PENDIDIKAN KIMIA
ISSN: 2085-3653| e-ISSN: 2549-3116

J. Pendidik. Kim 14(3): 180-186
DOI 10.24114/jpkim.v14i3.39788

Research Article

The effect of argumentation-oriented learning models, inquiry-based learning models and science process skills on students' argumentation ability in chemistry

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Received 08 November 2022 ♦ **Revised** 26 December 2022 ♦ **Accepted** 26 December 2022

Citation: Fitri, N.R., Rusdi, M., & Effendi-Hsb, M.H. (2022). The effect of argumentation-oriented learning models, inquiry-based learning models and science process skills on students' argumentation ability in chemistry. *Jurnal Pendidikan Kimia (JPKim)*, 14(3), 180-186. https://doi.org/10.24114/jpkim.v14i3.39788

Keywords

Argumentation ability
Argument driven inquiry
Argumentative inquiry blended learning
Guided inquiry-based learning
Science process skills

OpenAcces

Abstract

One of the models whose learning syntax matches the science process skill component and students' argumentation ability is the inquiry model. Inquiry models have been widely applied, such as Guided Inquiry Based Learning (GIBL), and modified, such as the Argument Driven Inquiry (ADI) and Argumentative Inquiry Blended Learning (AIBL) learning models, where the ADI and AIBL learning models in the learning syntax have been integrated with argumentation activities. The purpose of this study was to examine the effect of learning models and students' science process skills on students' argumentation ability. The research design used a 3 x 2 factorial design with a mixed method. The results showed that: (1) there was an effect of argumentation-oriented learning on the inquiry learning models on students' argumentation ability; (2) there is an effect of science process skill level on students' argumentation ability; and (3) there is no interaction between argumentation-oriented learning on the inquiry learning models and the level of science process skill on students' argumentation ability.

Introduction

Argumentation ability is related to a student's understanding of the material. Teachers can see the progress of their students' knowledge through the argumentation activities that are expressed. In addition, when students can express the results of their thoughts, these activities can affect their memory. That is, argumentation ability can also affect student learning outcomes (Angeline et al. 2018). So, argumentation ability has been used as educational standards and as criteria for assessing students (Heng et al. 2015). This activity shows that argumentation ability must be realized in the learning process for students so that communication skills get better and 21st century competencies can be realized (Siregar & Pakpahan, 2020).

Based on the results of an interview with the chemistry teacher at Al-Falah High School Jambi City, it was found that the student's overall argumentation ability was not good. This can be seen in the many students who make statements without being able to show scientific evidence or good reasons. Example: "Which of the solutions in the table (table lamp flame test) are classified as electrolyte and nonelectrolyte solutions?" Then the student gave statements and data such as "It was from the light of the lamp and a lot of bubbles." But when asked the reason "why?" they couldn't answer. This means the argumentation skill of students is still relatively low, as they are only able to make claims without any reason that is able to connect scientific statements and evidence.

In learning chemistry, science process skills are important to development. Through science process skills, students learn like a scientist who carries out various scientific procedures to prove theories. Science process skills can be trained in learning by choosing a suitable and appropriate learning model to be able to develop these skills. This is the same thing that was also expressed by Guswita et al. (2018) and Gobel et al. (2019), that the selection of the right method is expected for the development of students' science process skills.

One of the learning models whose learning syntax is similar to the science process skills components is the inquiry model. The syntax of the inquiry model has the same objectives and components as the science process skills approach, where the activities of inquiry not only develop students' intellectual skills but also all of their potential, including their emotional development and the development of skills that exist in science process skills itself. So, it can be concluded that inquiry learning is suitable for improving students' science process skills and scientific argumentation abilities (Nasution et al. 2018; Perangin-angin et al. 2019). Based on the results of an interview with the chemistry teacher at Al-Falah High School Jambi City, it was found that they had ever used the inquiry learning strategy in a chemistry lesson. This means that students already know how to use the inquiry learning strategy. So, scientific process skills and argumentation ability can be improved.

Inquiry-based learning aims to teach students to research and explain an event (Ramandha et al. 2018). Students use their thinking skills to learn, solve problems, and practice what they have learned. Guided inquiry learning gives students the freedom to develop their own concepts and solve their problems in groups. Besides being able to improve students' argumentation ability, guided inquiry learning models can also affect science process skills. This is in accordance with Laliyo et al. (2020) and Hidayati and Yonata (2019), who found that the guided inquiry learning model is not only effective for training science process skills but can also improve learning outcomes.

The argument-driven inquiry (ADI) learning model is also effective for improving science process skills and scientific argumentation ability. Although both are inquiry-based, the ADI learning model is different from the general inquiry model because it has been integrated with argumentation activities that can help students understand how to make scientific explanations specifically, how to generalize scientific facts, how to use data to answer research questions, and how to reflect on the results of the investigations that have been carried out (Sampson Gleim. 2009). This difference is what distinguishes the implementation between the ADI model and the guided inquiry learning model.

The ADI learning model is usually used in the classroom or with a face-to-face system. Effendi-Hasibuan et al. (2019a) report obstacles to the ADI model, especially the lack of time at the argument production stage, so an innovation is needed to solve this problem (Effendi-Hasibuan et al. 2019b). Innovation, such as designing the model with blended learning, is in accordance with Divena et al. (2021) research, who carried out the ADI model independently online.

According to the two studies above, the innovation between the inquiry model and blended learning can be found in the research of Purba et al. (2021). In her research, she found that the development of the inquiry learning model syntax combined with the flipped classroom (online learning) learning model resulted in a new learning model innovation to improve students' argumentation abilities, which she named the "argumentative inquiry blended learning" (AIBL) model. The AIBL model combined learning activities at home (online) with learning activities in the classroom. So, based on the description above, the purpose of this study is to find the effect of argumentation-oriented learning models, inquiry-based learning models, and science process skills learning models on students' argumentation abilities in chemistry.

Method

The research method used in this study was an intergroup factorial design (between groups) 3×2 design, which refers to Rusdi (2020). This design was not only able to seed the impact of independent variables, but also the interaction between the independent variables on the dependent variable. The population used in this study were all students in class X IPA at Al-Falah High School Jambi City in the even semester of the 2021/2022 academic year, which consists of 3 classes. The research design used can be seen in Table 1.

Table 1. Factorial research design

	A_1	A_2	A_3
B_1	YA_1B_1	YA_2B_1	YA_3B_1
B_2	YA_1B_2	YA_2B_2	YA_3B_2

A_1 : AIBL Model
A_2 : ADI Model
A_3 : GIBL Model
B_1 : High Science Process Skill
B_2 : Low Science Process Skill
YA_1B_1 : Argumentation abilities of cells A_1 and B_1, applied to the explanation of other cells

This study has two independent variables: the learning model with 3 levels (AIBL model, ADI model, and GIBL model) and the category of students' science process skills (high and low). The dependent variable in this study is the student's argumentation skill. The data collected in this study includes data on science-process skills taken before being given treatment through tests. The data obtained was then analyzed into two categories, namely, the high student's science process skills category and the low student's science process skills category. Meanwhile, the data on student learning outcomes from essay tests on the argumentation ability of redox reaction were collected from the pretest (given at the beginning of the meeting) and posttest (given at the end of the meeting) and then analyzed using the SPSS program to look for ANOVA hypothesis testing.

Results and Discussion

The results of the science process skills test, pretest, and posttest on the argumentation skill of students on redox reactions can be seen in Table 2. Based on the results of Table 2, that the average science process skills scores are not much different between each class.

Table 2. Recapitulation of the science process skills test

Class	Category of students' science process skills	Amount	Average
GIBL	High Low	25 7	54.59
ADI	High Low	27 5	54.10
AIBL	High Low	27 5	54.88

Based on the results of Table 3, that the argumentation ability of students at the beginning is still low and has almost the same average. Meanwhile, the results of the posttest can be seen in Table 4.

Table 3. Recapitulation of the pretest

Class	Average	Level of Argumentation				
		1	2	3	4	5
GIBL	19.27	88.20	8.70	3.11	-	-
ADI	19.06	87.73	12.27	-	-	-
AIBL	19.48	82.17	16.56	1.27	-	-

Table 4. Recapitulation of the posttest

Class	Averange	Level of Argumentation				
		1	2	3	4	5
GIBL	73.13	-	-	43.23	47.92	8.85
ADI	77.60	-	2.08	23.44	58.85	15.63
AIBL	82.50	-	-	22.40	42.71	34.90

Based on the results of Table 4, that the value of posttest students in each class is different and has increased, where the AIBL class has the highest average of 82.50, the ADI class of 77.60, and the GIBL class of 73.13. So, the AIBL model has a better average score than the class that applies the GIBL and ADI models. To answer the three research hypotheses, it can be seen from the two-way ANOVA in Table 5.

Table 5. Results of two-way ANOVA

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2486.696[a]	5	497.339	22.234	.000
Intercept	580218.710	1	580218.710	25938.996	.000
Science Process Skills	1044.582	1	1044.582	46.699	.000
Models	1407.174	2	703.587	31.454	.000
Science Process Skills * Models	34.939	2	17.470	.781	.461
Error	2013.173	90	22.369		
Total	584718.579	96			
Corrected Total	4499.869	95			

a. R Squared = .553 (Adjusted R Squared = .528)

In the Corrected Model column, all the effects of independent variables are combined on the results of the argumentation skill test and have a significance value of <0.05, which means that the model is valid.

In the Science Process Skills column above, the significance value is <0.05, meaning that there is an influence on the student's science process skills level on the student's argumentation ability. These results answer the second hypothesis of this study that the level of science process skill has a significant effect on students' argumentation ability.

Argumentation is a systematic exploration of a theoretical confirmation through the coordination of evidence that describes the results of empirical observations or experimental results about natural phenomena (Bell and Linn, 2000). Science process skills are a way of thinking used by scientists in the discovery and construction of knowledge to solve problems and formulate results that occur spontaneously in our minds (Özgelen, 2012). Science process skills have a relationship with student learning outcomes. This is in accordance with Khery et al. (2019) research that finds a positive correlation between science process skills and learning outcomes. The skill is beneficial for the students not only in doing learning activities during the classroom process but also in solving real problems in daily life (Herda et al. 2020). The students will be able to find and develop their facts and concepts, as well as grow and develop attitudes and values that should be achieved by students. By conducting independent experiments, students will be more appreciative, unlike the case if they are only listening or just reading, and they can also optimize technology as a medium for fun learning. Activities in optimizing technology are the main character of 21st-century learning. This activity is relevant to the connectivism learning theory, which states that learning activities are a process of connecting various sources of information obtained during learning so that they can shape students to be able to think more critically when receiving information obtained during learning (Rusdi, 2018), especially information from internet sources.

In the Models column above, the significance value is < 0.05, which means that there was an effect of argumentation-oriented learning on the inquiry learning models on students' argumentation ability. These results answer the research's first hypothesis that the argumentation-oriented learning on the inquiry learning models has a significant effect on students' argumentation ability. So, it can be concluded that with increasing students' argumentation ability, their cognitive abilities will also increase.

The argumentation activity can make it easier for students to form the concept itself. This activity is in line with the constructivism learning theory that students must work to solve problems, find things for themselves, and try hard with ideas so that students can build new concepts and new knowledge independently (Silaban, 2021). Students with low argumentation skills will not be able to compete in an increasingly advanced world and will lose good job opportunities (Hasnunidah et al. 2015). For this reason, argumentation skills are needed. Argumentation skills are used by someone to analyze information about a topic, then the results of the analysis are communicated to others (Sumarni et al. 2017). To find out how the improvement of the student's argumentation ability between before and after learning can be seen from the N-Gain test in Table 6.

Table 6. Results of N-gain test

Class	N-Gain Score	N-Gain Percent	Category
GIBL	0.66	66	Currently
ADI	0.72	72	Height
AIBL	0.78	78	Height

Based on Table 6 above, the GIBL model is quite effective in improving students' argumentation ability, while the ADI model and AIBL model are also effective at improving argumentation ability. This happened because the classroom learning process that applied the AIBL and ADI models has been integrated with the activity of arguing in learning syntax so that could help students to understand, then how to make scientific explanations, how to generalize scientific facts, use data to answer research question, and reflect on the results of investigations that have been carried out (Sampson and Gleim, 2009).

The current syntax of the ADI model consists of the following steps: (1) the identification of a task by the teacher that creates a desire for the students to resolve a problem from a phenomenon, (2) generalization of data that students do in groups to develop and apply data collection methods to solve problems or to answer the investigative questions posed in the first step, (3) the production of a tentative argument, (4) an argumentation session where groups share their arguments and then critique and refine their explanations, (5) an explicit and reflective discussion about the inquiry, (6)) a written investigation report, (7) a double-blind peer review of these reports to ensure quality and to generate valuable feedback, (8) the subsequent revision of the report based on the results of the peer-review (Divena et al. 2021).

While the AIBL model combines blended learning and inquiry learning. At home (before class), (1) the teacher provides material, asks questions, and formulates hypotheses. Students are required to have prior knowledge through a description of the material provided by the teacher in the form of images, videos, and text online. Its goal is to help students understand the material by facilitating the learning process and the existence of questions and hypotheses; (2) giving argumentative examples; and (3) group division. The benefits of giving examples of arguments and dividing students into several heterogeneous groups to discuss the tasks that have been given by the teacher. At class (during class), (4) students collecting data; (5) analyzing data; (6) prepare claims/answers. Students sit in groups according to the groups that have been given by the teacher and begin to conduct discussion and argumentative group work by using the components of claims, evidence, and reasoning to complete or answer tasks or problems given by the teacher in previous learning activities; and (7) in class discussion, students conduct discussions between groups to strengthen their understanding of the material or topic of discussion given by the teacher. After class (8) teacher gave a reward for the best groups and continued with a posttest (Purba et al. 2021).

The GIBL model has experimental activities without special argumentation activities for students. The stages of the guided inquiry model consist of orientation, conceptualization, investigation, conclusion, and discussion. The GIBL model class, the researcher only included the argumentation component in the last syntax, namely communicating the experimental results, so that the measurement results were different from the students' argumentation abilities. Even though they have different learning syntax, the argumentation ability of students from the three classes increases because each class carries out investigative activities in the inquiry learning syntax. Students collect evidence for themselves based on their investigative findings and are trained to draw valid research conclusions based on the evidence gathered. This research is in line with Gunawan et al. (2021) and Marhamah et al. (2017), that students' argumentative abilities can be increased through scientific investigation activities.

The effectiveness of the learning model used can be seen in the table of t-test dependent results (Table 7). Based on Table 7 above, there is a significant difference between the values of the pretest and the value of the posttest. This difference can be understood as the impact or effect of the learning model used, that is, each has a different activity. So, it can be concluded that the application of the learning model used is the GIBL, ADI, and AIBL models, each of which is significant for improving students' argumentation abilities.

Table 7. Results of T-dependent test

		Paired Differences					T	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest GIBL - Posttest GIBL	-53.85375	7.19075	1.27116	-56.44629	-51.26121	-42.366	31	.000
Pair 2	Pretest ADI - Posttest ADI	-58.54156	5.86186	1.03624	-60.65499	-56.42814	-56.494	31	.000
Pair 3	Pretest AIBL - Posttest AIBL	-63.02062	8.31185	1.46934	-66.01737	-60.02388	-42.890	31	.000

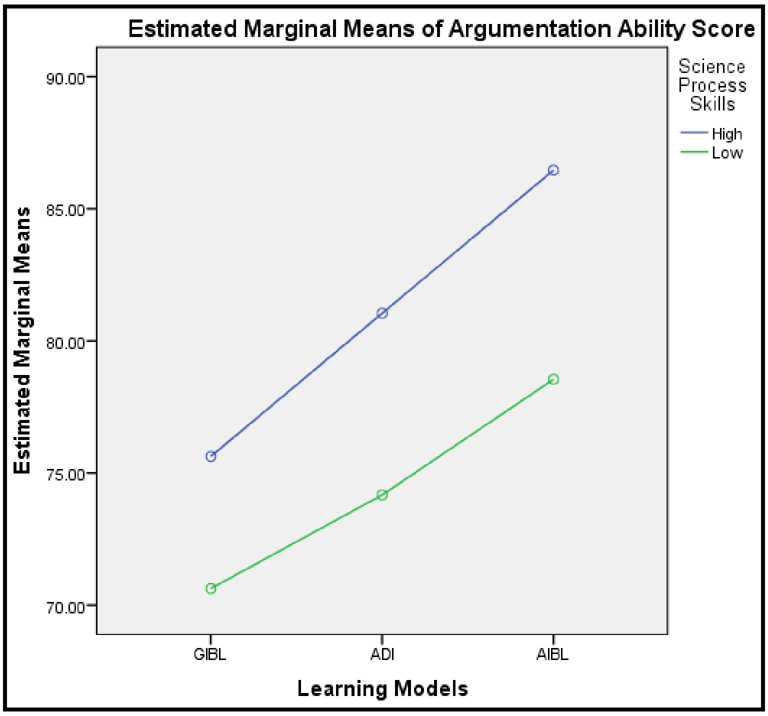

Figure 1. Interaction between learning models and science process skills

This is in accordance with Amelia at al. (2020) research, which in their research found that learning using the ADI model was more effective than the IBL model in improving students' argumentation abilities. The ADI model is effective in facilitating students by providing many opportunities to be directly involved in discussions and argumentative activities in the learning of syntax. Meanwhile, Hasnunidah and Wiono (2019), in their research that also compared the ADI model and the GIBL model, revealed that the ADI model was more effective in improving students' argumentation abilities than the guided inquiry model. This increase can be understood as the impact of the learning model activities used and the fact that ADI model argumentation activities have been integrated. So, the application of the GIBL, ADI, and AIBL learning models in redox reaction learning can improve students' argumentation abilities.

In the science process skills models column above, that has a significance value >0.05. It means that there is no interaction between argumentation-oriented learning on the inquiry learning models and the level of science process skill on students' argumentation ability. These results answer the third hypothesis of this study. The relationship between variables can be seen in Fig. 1. The interaction relationship between the learning models and the students' science process skills can be seen in Fig. 1 does not produce crosses or lines that do not intersect in this data. However, if seen from Fig. 1, there is an unequal slope to the line, so this situation indicates that research also has the potential to interact if the number of samples is increased. As a result of this data, argumentation-oriented learning in the inquiry learning model with the level of science process skill has an independent influence on students' argumentation abilities. So it can be interpreted that there is no significant interaction between argumentation-oriented learning in the inquiry learning model and the level of science process skill in terms of the students' argumentation abilities. The results obtained are in line with the research of Hardiyanto et al. (2015), which found that there is no interaction between learning models and science process skills on student learning outcomes; students who have high science process skills will have better learning outcomes than students who have low science process skills, even though the learning models applied are different.

Conclusion

Based on the results of the research, it can be concluded, there was an effect of argumentation-oriented learning on the inquiry learning models on students' argumentation ability, there is an effect of science process skill level on students' argumentation ability, and there is no interaction between argumentation-oriented learning on the inquiry learning models and the level of science process skill on students' argumentation ability.

Acknowledgment

The authors acknowledge the lecturers and students of chemistry education at Jambi University and Al-Falah High School Jambi City for their permission to obtain the research data.

References

Amelia, D. R., Asrial, A., & Effendi-hasibuan, M. H. (2020). The effectiveness of argument-driven inquiry in promoting students' argumentation ability about colloids. *Advances in Engineering Research*, 205, p. 328-335. https://dx.doi.org/10.2991/aer.k.210825.058

Angeline, V., Situmorang, R. P., & Sastrodihardjo, S. (2018). Korelasi keterampilan argumentasi dan hasil belajar siska SMA Kristen Satya Wacana pada materi genetika dengan model ABSI. *JIPVA (Jurnal Pendidikan IPA Veteran)*, 2(1), 1-12. https://doi.org/10.31331/jipva.v2i1.539

Bell, P., & Linn, M. (2000). Scientific arguments as learning artifacts: Designing for learning from the web with KIE. *International Journal of Science Education*, 22(8), 797-817. https://doi.org/10.1080/095006900412284

Divena, M. S., Hamdiyati, Y., & Aryani, A. (2021). Effectiveness of argument-driven inquiry (ADI) on students' concept mastery and argumentation ability in reproductive system. *Biosfer: Jurnal Pendidikan Biologi*, 14(2), 264-274. https://doi.org/10.21009/biosferjpb.20513

Effendi-Hasibuan, M. H., Bakar, A., & Harizon, H. (2019a). Skills to argue: Using argument-based learning (ABL) and socio-scientific issues to promote university students' argumentation ability in chemistry. *Journal of Physics: Conference Series*, 1567, p. 022042. https://doi.org/10.1088/1742-6596/1567/2/022042

Effendi-hasibuan, M. H., Harizon, H., Ngatijo, N., Fuldiaratman, F., & Sulistyo U. (2019b). Promoting Indonesian secondary school students' argumentation ability in the concept of chemistry reaction-rate: A comparative effect of three cooperative learning strategies. *Journal of Physics: Conference Series*, 1317, p. 012143. https://doi.org/10.1088/1742-6596/1317/1/012143

Gobel, A. I., Rumape, O., & Duengo, S. (2019). Pengaruh model pembelajaran inkuiri terbimbing bervisi sets terhadap keterampilan proses sains dan hasil belajar siswa pada materi larutan elektrolit dan nonelektrolit kelas X SMA Negeri 1 Gorontalo. *Jambura Journal of Educational Chemistry*, 1(1), 21-30. https://doi.org/10.34312/jjec.v1i1.2069

Gunawan, G., Purwoko, A. A., Ramdani, A., & Yustiqvar, M. (2021). Pembelajaran menggunakan learning management systemberbasis moodle pada masa pandemi covid-19. *Indonesian Journal of Teacher Education*, 2(1), 226-235.

Guswita, S., Anggoro, B. S., Haka, N. B., & Handoko, A. (2018). Analisis keterampilan proses sains dan sikap ilmiah peserta didik kelas xi mata pelajaran biologi di SMA Al-Azhar 3 Bandar Lampung. *Jurnal Tadris Pendidikan Biologi*, 9(1), 249-258. https://doi.org/10.24042/biosfer.v9i2.4025

Hardiyanto, H., Susilawati, S., & Harjono, A. (2015). Pengaruh model pembelajaran berbasis masalah dan ekspositori dengan keterampilan proses sains terhadap hasil belajar fisika siswa kelas viii MTsN 1 Mataram tahun ajaran 2014/2015. *Jurnal Pendidikan Fisika dan Teknologi*, 1(4), 249-256. https://doi.org/10.29303/jpft.v1i4.267

Hasnunidah, N., Susilo, H., Henie Irawati, M., & Sutomo, H. (2015). Argument-Driven inquiry with scaffolding as the development strategies of argumentation and critical thinking skills of students in Lampung, Indonesia. *American Journal of Educational Research*, 3(9), 1185-1192.

Hasnunidah, N. & Wiono, W. J. (2019). Argument-driven inquiry, gender, and its effects on argumentation ability. *Jurnal Keguruan dan Ilmu Tarbiyah*, 4(2), 179-188. https://doi.org/10.24042/tadris.v4i2.4676

Heng, L. L., Surif, J., & Seng, C. H. (2015). Malaysian students' scientific argumentation: do groups perform better than individuals?. *International Journal of Science Education*, 37(3), 505–528. https://doi.org/10.1080/09500693.2014.995147

Herda, A., Johari, A., Maison, Rusdi, M., & Asyhar, R. (2020). Science process skill ability level of senior high school students in learning chemistry in Jambi. *International Journal of Scientific & Technology Research*, 9(4), 1829-1833.

Hidayati, N. & Yonata, B. (2019). Penerapan model pembelajaran inkuiri terbimbing untuk melatihkan keterampilan proses sains peserta didik pada materi kesetimbangan kimia kelas xi SMAN Ngoro Jombang. *Unesa Journal of Chemical Education*, 8(2), 148-155. https://doi.org/10.26740/ujced.v8n2.p%25p

Khery, Y., Pahriah, Jailani, A. K., Rizqiana, A., & Iswari, N. A. (2019). Korelasi keterampilan proses sains dengan hasil belajar mahasiswa pada praktikum kinetika reaksi. *Hydrogen: Jurnal Kependidikan Kimia*, 7(1), 46-53. https://doi.org/10.33394/hjkk.v7i1.1686

Laliyo, L. A. R., Mian-Kau, La-Kilo, J., & La-Kilo, A. (2020). Kemampuan siswa memecahkan masalah hukum-hukum dasar kimia melalui pembelajaran inkuiri terbimbing. *Ar-Razi Jurnal Ilmiah*, 8(1), 1-8.

Marhamah, O. S., Nurlaelah, I., & Setiawati, I. (2017). Penerapan Model argument-driven inquiry (adi) dalam meningkatkan kemampuan berargumentasi siswa pada konsep pencemaran lingkungan di kelas X SMA Negeri 1 Ciawigebang. *Quagga: Jurnal Pendidikan dan Biologi*, 9(02), 39-45.

Nasution, R., Silaban, S., & Sudrajat, A. (2018). The influence of problem based learning, guided inquiry learning models assited by lectora inspire, and scientific attitudes to student's cognitive values. *Advances in Social Science, Education and Humanities Research*, 200, p. 265-269. https://doi.org/10.2991/aisteel-18.2018.58

Özgelen, S. (2012). Students' science process skills within a cognitive domain framework. *Eurasia Journal of Mathematics, Science & Technology Education*, 8(4), 283–292. https://doi.org/10.12973/eurasia.2012.846a

Perangin-Angin, P. S., Hutabarat, W., & Silaba, S. (2019). The influence of practical guide based on inquiry approach toward students' achievement on pH scale and use of indicator subjects. *Advances in Social Science, Education and Humanities Research*, 384, p. 525-528. https://doi.org/10.2991/aisteel-19.2019.117

Purba, F., Harizon, H., & Effendi, M. H. (2021). Development of argumentative learning model procedures inquiry blended learning on acid-base materials. Jurnal Pendidikan dan Pembelajaran Kimia, 10(2), 46-60.

Ramandha, M. E. P., Andayani, Y., & Hadisaputra, S. (2018). An analysis of critical thinking skills among students studying chemistry using guided inquiry models. *AIP Conference Proceedings*, 2021, p. 080007. AIP Publishing LLC. https://doi.org/10.1063/1.5062826

Rusdi, M. (2018). Penelitian desain dan pengembangan kependidikan. Depok: PT. RajaGrafindo Persada.

Susdi, M. (2020). Penelitian perlakuan kependidikan. Depok: PT RajaGrafindo Persada.

Sampson, V., & Gleim, L. (2009). Argument-driven inquiry to promote the understanding of important concepts & practices in biology. *The American biology teacher*, 71(8), 465-472. https://doi.org/10.1662/005.071.0805

Siregar, N., & Pakpahan A. R. (2020). Kemampuan argumentasi ipa siswa melalui pembelajaran argument driven inquiry (ADI). *LENSA (Lentera Sains): Jurnal Pendidikan IPA*, 10(2), 94-103. https://doi.org/10.24929/lensa.v10i2.113

Silaban, S. (2021). Pengembangan program pengajaran. Medan: Yayasan Kita Menulis.

Sumarni, E. N., Widodo, A., & Solihat, R. (2017). Stimulating students' argumentation using drawing–based modeling on the concept of ecosystem. *In International Journal of Science and Applied Science: Conference Series*, 2(1), 98-104. http://dx.doi.org/10.20961/ijsascs.v2i1.16688