Indonesian Society for Science Educators
Journal of Science Learning
journal homepage: ejournal.upi.edu/index.php/jslearning

The Effect of Argument-Driven Inquiry (ADI) on Argumentation Skills and Students' Concept Mastering of Human Excretory System Materials

Vita Riyanti[1], Yanti Hamdiyati[1]*, Widi Purwianingsih[1]

[1]Department of Biology Education, Faculty of Mathematics and Natural Science Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

*Corresponding author: yhamdiyati@upi.edu

ABSTRACT This study aims to determine the effect of the Argument-Driven Inquiry (ADI) learning model on students' argumentation skills and mastery of concepts in human excretory system material, especially in the sub-material of kidney disorders. The research method used quasi-experimental with a group pretest-posttest design. The sample of this research was second-grade MIPA students in one of the high schools in Bandung, which consisted of 29 students in the experimental class and 25 students in the control class. The purposive sampling technique did the sampling. The study used some instruments, which consisted of a test of argumentation skills in the form of essay questions, an exam of mastery of concepts in the form of multiple choice, and a questionnaire on student responses to learning using the ADI learning model. The results showed that the ADI learning model had a more significant effect on argumentation skills in the experimental class than in the control class, with a significance value of 0.019. The quality of students' argumentation was at level 3. However, the ADI learning model did not significantly affect students' mastery of concepts in the excretory system material because a significant difference was not found between the pretest and posttest data in both research classes. Student response data shows students respond completely well to applying the ADI learning model. Therefore, the ADI learning model is recommended for biology teachers to improve students' argumentation skills and concepts mastery in other biological materials.

Keywords Argument-Driven Inquiry (ADI), Argumentation skills, Mastery of a concept

1. INTRODUCTION

The 21st century changes the quality of human resources. So individuals are required to have the ability to face new challenges due to globalization (Supriyati, Setyawati, Purwanti, Salsabila & Prayitno, 2018). During the last two decades, educational experts have tried to determine the abilities and skills needed for success in work and life in the 21st century, including creativity and innovation, collaboration, communication, critical thinking, and problem-solving (Paidi, 2020).

21st-century skills will be practical through education (Rendhana, 2019). Based on the decree of the minister of education and culture no. 22 of 2016, various aspects must be taught to students in the learning process, one of which is mental skills (soft skills). One of the soft skills needed in the 21st century is the ability to argue, which includes communication skills (Divena, Hamdiyati & Aryani, 2021). Arguing is a dialogic process in which conflicting or in-line claims meet, with dialogue mechanisms in which language users can demonstrate their abilities by using the knowledge acquired to communicate more effectively (Ubaque Casallas & Pinilla Castellanos, 2016). In their research, Duschl & Osborne (2002) stated that the main thing to underlie students in learning how to analyze evidence, test, evaluate, and draw conclusions to make decisions or solve problems is by arguing. When someone argues, that person will convey his ideas to others accompanied by reasons that contain existing data or evidence (Saracaloglu, Aktamis, & Delioglu, 2011). According to Lunenburg (2010), if someone can convey his ideas, then the person has good communication skills.

Argumentation skill is necessary for students mastery of concepts because it relates to knowledge and thinking skills (Bekiroglu & Eskin, 2012). Through argumentation activities, students' can apply the scientific knowledge they have learned in formal education (Bulgren, Ellis & Marquis, 2014). Erduran, Simon & Osborne, (2004) stated that the student needs arguments in every lesson. By

Received: 14 January 2023
Revised: 03 March 2023
Published: 31 March 2023

engaging in argumentation activities, students' can master concepts better because knowledge of the content discussed is necessary to build an opinion, so students are required to understand the content better (Adriani & Riandi, 2015). Students' ability to relate content obtained during the learning process shows the level of student's mastery of concepts (Noviyani, Kusairi & Amin, 2017), and good mastery of concepts will be able to improve student's argumentation abilities well (Divena, Hamdiyati & Aryan, 2021).

The 2013 curriculum has accommodated 21st-century skills, both in terms of content standards, process standards, and assessment standards. Still, the school environment often does not support students in developing the skills needed in the 21st century, such as argumentation skills. The learning process in several schools is still a direct transfer of knowledge from teacher to student (Salsabila, Wijaya, Winarno & Hanif, 2019). Few schools involve argumentation in learning (Erduran, Simon & Osborne, 2004). Teachers still carry out many learning activities using conventional learning presented verbally through lecture activities (Divena, Hamdiyati & Aryan, 2021). Muslim (2011) suggests that science learning is frequently presented verbally through lecture activities where the teacher is the primary source of learning and students only listen to the teacher's explanation which is called teacher-centered learning. In addition, learning is still book-oriented, so student involvement is minimal, making the impression of boredom and unattractive for students to learn. The conventional teaching and learning process only presents concept definitions to students, and students memorize without understanding the relationship between these concepts and other concepts (Lu, Bi & Liu, 2018). Then, conventional learning is considered ineffective in the quality of learning outcomes and does not help students to develop 21st-century skills, especially argumentation skills (Ruhulessin, Ratumanan & Tamalene, 2019).

According to Jayawardana (2015), the quality of learning outcomes is highly dependent on the learning process. The learning process will be more meaningful if the teacher and student interaction occurs optimally, where students are actively involved in the learning process through active learning. Through active learning, the practice of arguing can be a way of actively involving students in learning because the first stage in helping the development of student arguments is to create a learning environment where students are active and understand what will be done from discussions and align it with scientific arguments (Berland & Hammer, 2012; McNeill, 2011). Argumentation skills are needed as a necessary aspect of the active learning process because it helps students express their ideas and opinions so that students can solve problems that exist in the learning process (Marhamah, Nurlaelah & Setiawati, 2017).

The results of previous studies show that students' argumentation skills are still low (Admoko, Hanifah, Suprapto, Hariyono & Madlazim, 2021; Ekanara, Adisendjaja & Hamdiyati, 2018; Syerliana, Muslim & Setiawan, 2018; Utomo, Ashadi & Sarwanto, 2019). Supported research conducted by Fatmawati, Harlita & Ramli (2018) on 33 high school students in class X showed that 91% of 33 students were at a low argumentation level, namely level 1. Then, the results of Harianto's (2018) research showed that students' mastery of concepts and the quality level of arguments achieved by students were still relatively low. The results of this research become a challenge for teachers in the learning process to create learning activities that can facilitate students in developing 21st-century skills, especially argumentation skills. Therefore, a learning model-based inquiry is necessary for developing students' skills in the context of the 21st century, especially argumentation skills such as inquiry learning models, problem-based learning, the 5e learning cycle, and one of the alternative learning models used in this study is Argument-Driven Inquiry (ADI) developed by Sampson & Gleim (2009).

The Argument-Driven Inquiry (ADI) learning model is designed to structure scientific investigations to develop an argument that provides and supports an explanation for research questions (Sampson & Gleim, 2009). According to Demircioglu & Ucar (2015), the ADI learning model is different from other models because that provides opportunities for students to design and discover research results and engage in argumentation processes so that students can share and support each other's ideas. Their ideas can bring up new knowledge for the students (Antonio & Prudente, 2021). The ADI learning model provides opportunities for students to learn how to develop methods for generating data, conducting investigations, using data to answer research questions, writing, and conducting more reflective discussion activities after investigative activities have been carried out. Through a combination of all these activities, students have expected to be able to science learning, in this case, biology. Supported by the statement of Förtsch, Werner, Dorfner, von Kotzebue & Neuhaus, (2017) and Paidi (2020) that teaching must provide opportunities for students to learn by conducting investigations can obtain meaningful learning. The Argument-Driven Inquiry (ADI) model is considered an effective model for improving argumentation skills, including communication skills (Sampson et al., 2014).

Looking at the previous research on the application of the ADI learning models conducted by Adriani & Riandi (2015), the ADI learning model can improve mastery of concepts and argumentation skills in science lessons for class VII junior high school. Then, the results of research conducted by Divena, Hamdiyati & Aryan (2021) showed that the ADI learning model could improve each component argumentation by 44% on the reproductive system material. Kadayifci & Yalcin-Celik (2016) that the ADI learning model can improve the conceptual understanding of students about the concepts and skills of students' argumentation against chemical material. Likewise, research conducted by Eymur (2019) and Salsabila, Wijaya, Winarno & Hanif, 2019) states that the ADI learning model is effective and can increase understanding of the concept of the Nature of Science (NOS) and global warming in junior high school students.

Based on the results of observations of the biology learning process at a high school in Bandung, it is known that the learning process is still teacher-centered. Teachers usually use the lecture method in teaching biology materials, especially during the pandemic, the learning process is carried out online or using a limited face-to-face system divided into two class sessions, and students have also prohibited from carrying out activities in the laboratory or all kinds of learning outside the classroom. In addition, students are inactive in learning activities in the learning process. Students use memorization methods in learning without understanding the meaning, so they can only remember in the short term. In learning about organ systems, the teacher only briefly informs about abnormalities and diseases in human organ systems without relating them to daily activities. Thus, when faced with health problems of human organ systems, students are still confused about solving these problems due to limited information. Even though the health of the organ systems is essential, it is also related to the lifestyle one life. For example, rumors that jumping urine is fine for people who have difficulty urinating, especially the elderly. But the rumors about jumping urine have received clarification from the Ministry of Communication and Informatics that the stories were hoaxes in 2020. Other issues, such as urinary tract infections, are caused by drinking too many flavored drinks, etc., also circulating on social media. This issue will lead to a debate among students to find the correct answer to solve existing problems. Regarding content, based on Aprilanti, Qurbaniah & Muldayanti's (2016) research, there are several misconceptions about excretory system material, such as the lungs are excretory organs and excretory organs excrete toxins instead of metabolic waste products. Therefore, excretory system material with sub-material kidney disorders can be applied in learning with the ADI learning model.

Based on this explanation, the research was conducted on applying the ADI learning model through research entitled The Effect of Argument-Driven Inquiry (ADI) on Argumentation Skills and Students Concept Mastering of Human Excretory System Materials in class second-grade MIPA students at a high school in Bandung. Based on previous considerations, the sub-matter used in this study was kidney disorders with different treatments in the form of a learning model for class two research, namely the ADI learning model and inquiry learning. The inquiry learning used is included in the structured inquiry category because students are presented with problems and assisted in formulating steps to solve problems. However, the results of the inquiry are unknown (Widodo, 2021).

The excretion system in the 2013 Curriculum is included in Basic Competency 3.9 and 4.9. This material contains content on the human excretory system's structure, anatomy, function, and abnormalities. Excretory organs are essential in human life because they play a role in the body's homeostatic processes (Campbell & Reece, 2010). Therefore, this material is an important concept to discuss because it discusses one part of the organ system in the body so that the excretory system is included in learning materials in schools. Hopefully, this research can improve the quality of learning in schools, helping teachers, especially biology teachers' to apply Argument-Driven Inquiry (ADI) in learning so that they can train or improve students' skills and knowledge in solving problems and linking them with daily activities.

2. METHOD

The research method used in this study was quasi-experimental with a group pretest-posttest design. Before implementing classroom learning, pretest data was used to see students' argumentation skills and concept mastery. After giving a pretest to the two research classes and then given the treatment of applying the ADI learning model to the experimental class and inquiry learning to the control class, students' argumentation skills and concept mastery were re-measured by giving a posttest to re-measure students' argumentation skills and concept mastery whether there a change or increase compared to the value before given treatment. The pretest-posttest design group can be seen in Table 1.

Table 1 Group pretest posttest design

Class	Pre-test	Treatment	Post-test
Experiment	O_1	X	O_2
Control	O1	Y	O_2

Description :
O_1 = Giving a pretest at the beginning of learning
O_2 = Giving a posttest at the end of learning
X = The treatment was in the form of Argument-Driven Inquiry in the experimental class.
Y = Without Argument-Driven Inquiry treatment (Using inquiry learning model)

This research was conducted on students of class XI MIPA, consisting of 29 students from the experimental class and 25 from the control class. Sampling was done by purposive sampling technique. Adjusting to the pandemic situation, the practicum activities in this study used a virtual lab from Olabs Biology for both research classes. Practicum activities in the form of detection of the sugar, protein, and urea in the urine. Some examples of practicum

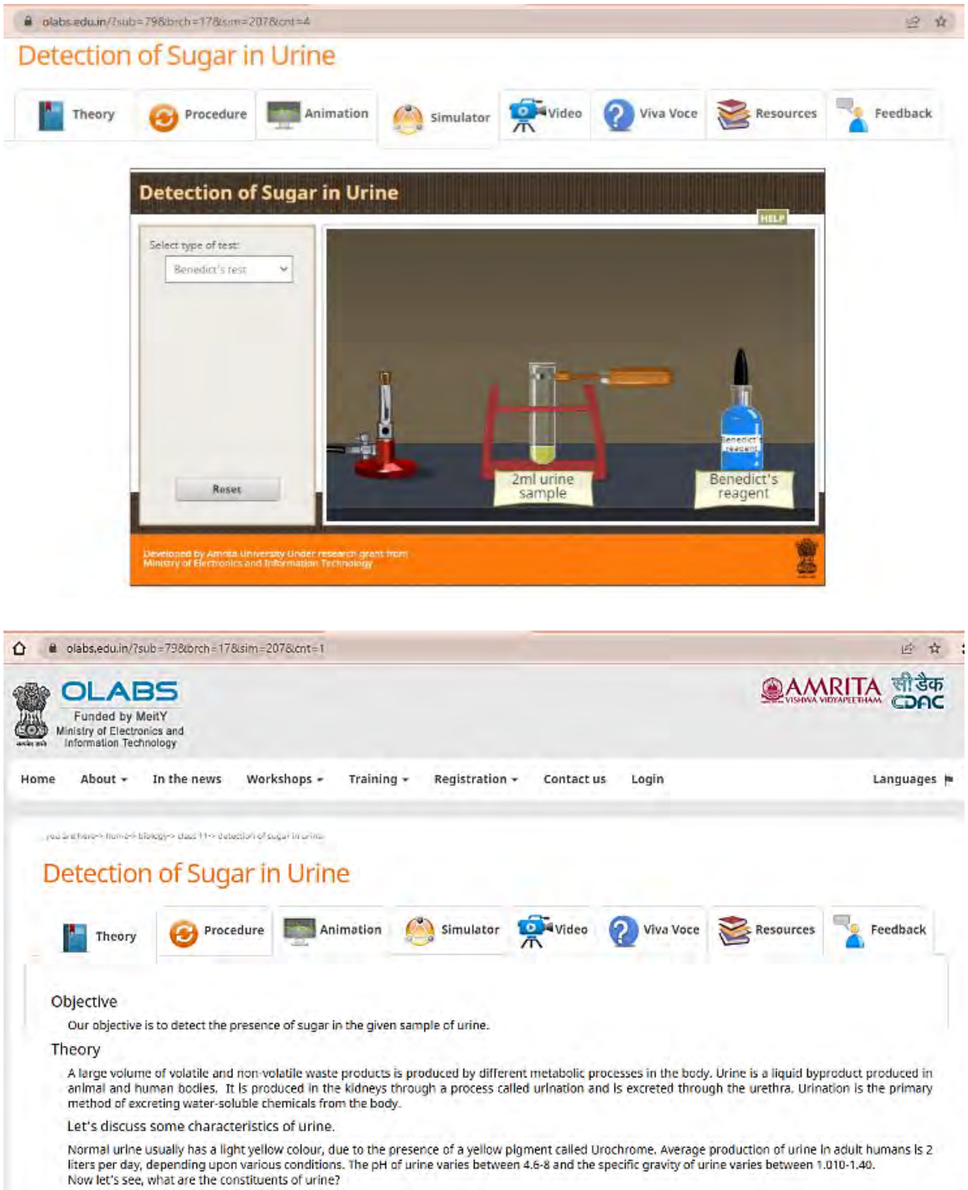

Figure 1 Practicum activities on the Olabs Biology

activities on the Olabs Biology website can be seen in Figure 1. The instrument consisted of an argumentation skill test in the form of essay questions totaling four items to measure the argumentation components: claims, data, warrants, and backing according to the question indicators developed by Sampson & Gerbino (2010) which can be seen in Table 2. In addition, a rubric for assessing the quality of argumentation skills based on the Toulmin Argumentation Pattern (TAP) in Osborne, Simon & Erduran (2004) is presented in Table 3. Concept mastery test in the form of multiple choice totaling 20 questions in the cognitive domain from levels C3 (apply), C4 (analyze), C5 (evaluate), and C6 (create). The questions on argumentation skills and mastery of concepts were tested before being used for research using the ANATES program application. Student response questionnaires to learning using the ADI learning model consisted of 10 positive and negative statements measured using a Likert scale. Positive statements with the highest score are categorized as "Strongly Agree", while negative statements

Table 2 Indicator of argumentation skills

No.	Argumentation components	Indicator
1	Claim	Make accurate claims according to the problems discussed
2	Data	Analyze data to support claims
3	Warrants	Explain the relationship between data and claims in the form of warrants
4	Backing	Underlying justifications to support claims in the form of backing

Table 3 Scientific argumentation skills analysis framework

Level	Criteria
1	The argument contains one claim against another.
2	Arguments have arguments from one claim against another claim with data, warrants, and backing, but do not contain rebuttals.
3	The argument has arguments with a weak series of claims, data, warrants, backing, and rebuttals.
4	Argumentation shows an argument with a clear rebuttal and contains several claims.
5	Arguments present extended arguments with more than one clear rebuttal.

(Osborne, Simon & Erduran, 2004)

with the lowest score are classified as "Strongly Disagree". The greater the percentage obtained, the better the learning response using the ADI learning model.

The scoring technique for pretest, posttest and questionnaire percentages uses the following formula,

$$\text{Final score} = \frac{total\ score}{maximal\ score}\ x\ 100\%$$

Then, the data that has bee n obtained in the form of quantitative data is processed using the SPSS version 25 and Ms. Excel.

3. RESULT AND DISCUSSION

3.1 Differences in Students' Argumentation Skills between the Experimental Class (ADI Model) and the Control Class (Inquiry Learning Model)

In Table 4, the average pretest score of the argumentation skills of the experimental class is greater than that of the control class. If categorized into the category of cognitive level, according to Arikunto (2009), both research classes have a low level of initial argumentation skills. Most likely the learning process in class, students are not accustomed to making arguments but has only directed to ask questions. That is in line with what was explained by Bulgren, Ellis & Marquis (2014) that the learning process that facilitates student arguments is only limited to questions and answers; statements in the form of claims, rebuttals, or reinforcement are still not implemented because the learning process rarely carries out discussions in class. A learning process like this results in students' weak argumentation skills and difficulty giving warrants and backing to support claims (Sari, Musthafa & Yusuf, 2021). Then, the Asymp.Sig value α > 0.05, which is 0.220, then H_0 is accepted, which means there is no significant difference between the pretest scores in the two research classes. Thus, it concluded that the students' initial argumentation skills in the experimental and control classes were the same.

In Table 4, the posttest Asymp.Sig α value < 0.05, which is 0.019, means there is a significant difference in the average posttest score of the argumentation skills of the two research classes. Thus, applying the ADI learning model influences students' argumentation skills. This is in line with research by Demircioglu & Ucar (2015), Safira,

Table 4 Recapitulation of students' argumentation skills results

Component	Pre-test		Post-test	
	Control	Experiment	Control	Experiment
N	25	29	25	29
Mean	29,50	35,77	48,50	64,65
SD	17,26	16,27	24,02	24,33
Min. value	0,0	12,5	12,50	12.50
Max. value	62,5	75,0	87,50	100.00
Normalitas Test (*Shapiro-Wilk*)	Sig α > 0.05, Data is normally distributed			
Significance Value	0,007	0,187	0,098	0,021
Conclusion	Data is not normally distributed	Data is normally distributed	Data is normally distributed	Data is not normally distributed
Homogeneity Test (*Lavene statistic*)	Sig α > 0.05 homogeneous data			
Significance Value	0,901		0,904	
Conclusion	homogeneous data		homogeneous data	
Hypothesis Test (*Mann Whitney U*)	Asymp.Sig α > 0.05 H_0 accepted			
Significance Value	0, 220		0,019	
Conclusion	H_0 accepted		H_0 rejected	

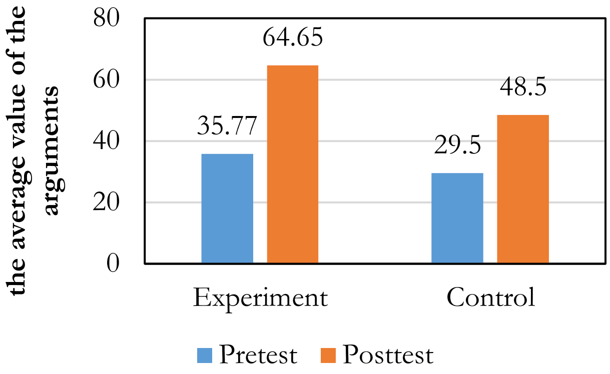

Figure 2 Comparison of the argumentation skills of the experimental class and the control class

Hasnunidah & Sikumbang (2018), Kadayifci & Yalcin-Celik (2016), and Divena, Hamdiyati & Aryan (2021) that the ADI learning model has a significant influence on argumentation skills, evidenced by an increase in the argumentation skills of the experimental class compared to the control class.

The posttest values of both research classes experienced an increase compared to the pretest values before treatment. Figure 2 shows that the ADI class improves students' argumentation skills more than the class that uses the inquiry learning model, with a difference of 16.15. So the ADI model is more effective for improving students' argumentation skills than inquiry learning (structured inquiry). What distinguishes the results of increasing the value of argumentation is several stages of the ADI learning model not found in the inquiry learning model. These stages can facilitate students to argue, namely the tentative argument production stage and argumentation sessions (Demircioglu & Ucar, 2015; Marhamah, Nurlaelah & Setiawati, 2017). In this stage, students must relate their findings to information previously obtained (Farida, Undang & Hasnunidah, 2018), so they can develop the habit of scientific thinking and critical thinking to solve problems with argumentative activities (Divena, Hamdiyati & Aryan, 2021).

In producing tentative arguments, students are guided to make arguments. Then, each group member makes their argument, and the results of the arguments made individually are combined into group arguments. So, starting from this stage, students can convey and exchange their ideas through the statements they make but still within the scope of their respective groups. At this stage, students can develop basic knowledge to obtain evidence in making claims for an argument (Sampson et al., 2014). Claims and reasons presented by students are the results of students' thinking after understanding the problems in the argumentation sheet. According to Walker, Sampson & Zimmerman (2011), the argumentation components integrated into this stage are the warrant and backing components. The scene after the activity of producing arguments is the argumentation session. At this stage, students hold debates between groups where students can communicate their arguments, criticize arguments, improve argument explanations, and compile investigative reports according to the student worksheets provided. At this stage, the teacher acts as a mediator (Sampson et al., 2014). According to Bekiroglu & Eskin (2012), students with the best initial knowledge can provide the most argument contributions and have the best quality of arguments; vice versa, students with the lowest initial knowledge can contribute a small number of arguments and low quality.

Meanwhile, in the structured inquiry model (inquiry learning), students are immediately directed to conclude after collecting data by doing a practicum. In inquiry learning, students only communicate the results of their training and then conduct a question-and-answer session regarding the results of the practicum and the content of the excretory system material. Thus, there are no argumentation sessions to train students' skills in making arguments in the learning process. This difference distinguishes the implementation of the ADI learning

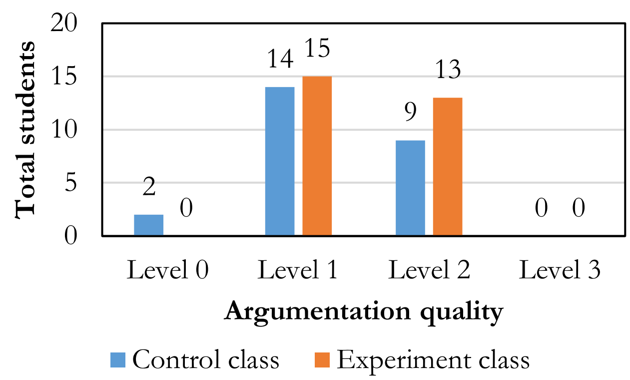

Figure 3 Comparison of the quality/level of students' initial arguments (pretest) in the experimental class and the control class

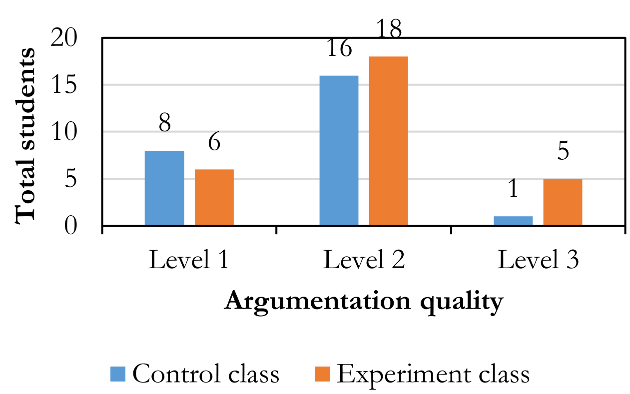

Figure 4 Comparison of quality/level of final argumentation (posttest) of experimental class and control class

model from the inquiry learning model. This ADI learning model can teach students how to make good and correct arguments (Walker, Sampson & Zimmerman, 2011).

The quality of student arguments was analyzed based on the argumentation components found on student answer sheets. The analysis results of students' argumentation levels in the experimental and control class can be seen in Figure 3 (initial argument) and Figure 4 (final argument).

Figure 3 and Figure 4 show that the quality of students' arguments has increased in both research classes. At the pretest, the quality of the ideas achieved by the students was mainly at level 1, and no one was at level 3. But after the treatment, the quality of the arguments achieved by the students was mostly at level 2, and some were at level 3.

In this study, the argumentation sheets only measured four argument components: claims, data, warrants, and backing. Therefore, initially, students were not able to compose rebuttals. Still, after being given the exact treatment after carrying out the stages of the ADI, namely explicit and reflective discussions, several students were able to make rebuttals even though the rebuttals they made were still weak and wrote them down at the time of revision of the report so that the argumentation skills of some students some reach level 3.Therefore, the results of this study are in line with research conducted by Ekanara (2014), that the level of argumentation skills of high school students ranges between level 3 and level 4 and proves that high school students can provide warrants, backing, and rebuttals although still weak according to the claims made.

In the two research classes, there were no students whose argumentation quality was at level 4 and level 5. That could be because students still had difficulty giving strong rebuttals and qualifiers following the claims made. Overall, the student answers were oriented toward a statement of claim, and some students did not provide argumentation statements included in the argumentation component category following TAP. To achieve quality argumentation at level 4 and level 5, students have to think more critically about a phenomenon and make possibilities from facts and student experiences related to the material studied (Sari, Musthafa & Yusuf, 2021).

3.2 Differences in Students' Mastery of Concepts between the Experimental Class (ADI Model) and the Control Class (Inquiry Learning)

In Table 5, the average pretest value for the experimental class is greater than the control class. With the results of these average scores, the student's mastery of concepts in the two research classes was categorized as sufficient based on a cognitive level, according to Arikunto (2009). However, students still rely on their prior knowledge of excretory system material learned in junior high school or prior knowledge obtained from self-taught learning outcomes. In addition, the results of the pretest differences in the experimental and control class were not significantly different. This show that students' mastery of concepts in the testing and control class before treatment was not much different.

After the research treatment, the posttest average scores of the two research classes were categorized as high according to Arikunto's (2009) cognitive level category. Then, after a different test, H0 was accepted. This show that the mastery of the two research classes after the treatment was not significantly different. Thus, the

Table 5 Recapitulation of students' concept mastery results

Component	Pre-test		Post-test	
	Control	Experiment	Control	Experiment
N	25	29	25	29
Mean	45,60	48,62	74,60	79,66
SD	16,41	14,44	14,50	17,97
Min. value	25	25	40	30
Max. value	75	80	100	100
Normalitas Test (*Shapiro-Wilk*)	Sig α > 0.05, Data is normally distributed			
Significance Value	0,028	0,171	0,499	0,002
Conclusion	Data is not normally distributed	Data is normally distributed	Data is normally distributed	Data is not normally distributed
Homogeneity Test (*Lavene statistic*)	Sig α > 0.05 homogeneous data			
Significance Value	0,355		0,414	
Conclusion	homogeneous data		homogeneous data	
Hypothesis Test (*Mann Whitney U*)	Asymp.Sig α > 0.05 H_0 accepted			
Significance Value	0,406		0,079	
Conclusion	H_0 accepted		H_0 rejected	

application of the ADI learning model did not significantly affect students' mastery of concepts even though the average posttest score of the experimental class was higher than the posttest average value of the control class.

The absence of a significant influence can be influenced by the learning model used in the two research classes and other factors that affect students' ability to absorb knowledge during the learning process. The two research classes used an inquiry-based learning model. The experimental class used the ADI learning model, and the control class used the inquiry learning model, where there were several similarities in the learning stages. The inquiry-based learning model is centered on student activity. Inquiry-based learning encourages students to learn independently by conducting experiments to investigate problems (Pedaste et al., 2015).

In the learning model stages of the two research classes, students are directed to conduct laboratory or practicum activities. In addition, the ADI learning model has tentative argument-making and argumentation sessions where students are given space to explore and stimulate thinking skills. In this session, students are trained to make arguments, so through this activity, students' mastery of concepts is emphasized (Divena, Hamdiyati & Aryan, 2021). Through the argumentation process contained in the stages of the ADI learning model, students can develop new understandings based on ideas put forward by others (Antonio & Prudente, 2021). In the inquiry learning model, there are stages of formulating problems, collecting data by planning and carrying out investigations, and associating (Widodo, 2006). Like the ADI model, this inquiry learning model provides opportunities for students to build their concepts actively. Although, in the inquiry learning model, students tend only to convey their findings and carry out question-and-answer activities. Both of these learning models require students to understand concepts based on the problems they face and find their solutions based on observations obtained from practicum activities Sumiyati, Yeni & Marlina, 2016).

In the early activities, both in the ADI and the inquiry learning models, the teacher attracted students' attention to disorders of the excretory system. In the ADI learning model, the first stage is task identification. In this stage, the teacher guides students to connect their prior knowledge with the topics discussed and relates them to the research questions (Sampson & Gleim, 2009). The initial stage of the ADI model is the same as the orientation stage and formulates problems in the inquiry learning model. For example, in the experimental class, students in groups identified issues in the student worksheet discourse and made their own investigative/practical questions. In the control class, students were presented with pictures of differences in urine color and were directed to complete research questions. The initial stages of these two models aim to get students to start learning new topics to investigate (Pedaste et al., 2015).

The next stage in the ADI learning model is data generalization. At this stage, students are directed to determine their data analysis methods and design investigative activities independently (Sampson et al., 2014). The second stage of the ADI model is the same as the stage of collecting data in the inquiry learning model. In practice, this data collection activity is carried out by practicing and searching for information on the internet. The practicum is carried out in a blended learning manner, namely independent practicum at home (asynchronous) and in groups using the virtual lab from Olabs Biology in class (synchronous). Independent internship conducted by students makes the learning process more contextual because it involves directly finding the material being studied and relating it to real-life situations (Kaunang, 2018). This activity encourages students to find answers to the problems they face using logical thinking skills (Yolanda, Gunawan & Sutrio, 2019) so that students are required to explore knowledge about the content discussed to solve problems (Sumiyati, Yeni & Marlina, 2016)

The inquiry process in the ADI model is founded on student arguments. During argumentation sessions, students work in groups to make tentative arguments (Salsabila, Wijaya, Winarno & Hanif, 2019). In this stage, they will form their conceptual understanding. The opinions they make need to be supported by the concepts underlying the phenomena are investigated, so the arguments put forward can be trusted (Muhiddin, 2015).

In the inquiry learning model, mastery of concepts is emphasized during collecting data and associating/reasoning. In this stage, students do an analysis to answer research questions. In line with the research of Yolanda, Gunawan & Sutrio (2019) and Akhmalia, Maharta & Suana (2018), learning using the inquiry model significantly affects students' mastery of concepts. Therefore, learning with this inquiry model is very suitable and can be used effectively in classroom learning (Shanmugavelu, Parasuraman, Ariffin, Kannan & Vadivelu, 2020).

The ADI and inquiry learning model are based on the social constructivist learning theory, which states that learning involves social and personal processes (Eymur, 2019). In terms of group work, in both the ADI model and the applied inquiry learning model, students with higher academic ability must provide scaffolding to students with lower academic ability in their group. The effective structure of students with higher and lower intellectual skills can make students with lower theoretical knowledge achieve higher learning outcomes (Safira, Hasnunidah & Sikumbang, 2018). Cooperation between group members went well. They divide tasks into data collection, the distribution of practicum implementation, and the preparation of practicum reports and data to strengthen the arguments made. In addition, during the learning process, students were very enthusiastic when doing virtual labs. The appearance of the web is most attractive, and it does not create a boring impression during learning. The virtual lab helps increase students' interest in learning to achieve satisfactory learning outcomes. Supported by research by Yolanda, Gunawan & Sutrio (2019) that using virtual laboratories can improve students' mastery of concepts.

3.3 Student Responses to Learning Using the Argument-Driven Inquiry (ADI) Learning Model

Student response to learning using ADI was obtained from a questionnaire from the experimental class. The overall results of the student response questionnaire data showed that almost all students in the practical class responded quite well, with an average score of 38.2. So, it can be said that students in the experimental class are pretty interested in applying the ADI model in learning biology on the excretory system material.

4. CONCLUSION

The ADI learning model significantly affected argumentation skills in the experimental class compared to the control class, and the quality of students' arguments was at level 3. However, it was not found between the pretest and posttest the ADI learning model did not significantly influence students' mastery of concepts because of a significant difference in results data on the two research classes, even though the posttest average score for the experimental class was higher than the control class posttest average score. ThBut, thenstudent response data s

ACKNOWLEDGMENT

The authors acknowledge the students and teachers of high school students in one of the public high schools in Bandung City, Indonesia, for permission to obtain the research data.

REFERENCES

Admoko, S., Hanifah, N., Suprapto, N., Hariyono, E., & Madlazim, M. (2021). The implementation of Argument Driven Inquiry (ADI) learning model to improve scientific argumentation skills of high school students. *Journal of Physics: Conference Series*, *1747*(1). https://doi.org/10.1088/1742-6596/1747/1/012046

Adriani, Y., & Riandi. (2015). Meningkatan Penguasaan Konsep Siswa Melalui Pembelajaran Argument Driven Inquiri pada Pembelajaran IPA Terpadu Di SMP Kelas VII [Improving Students' Mastery of Concepts Through Argument Driven Inquiry Learning in Integrated Science Learning in Class VII Junior High Schools}. *Edusains*, *7*(2), 114–120. https://doi.org/10.15408/es.v7i2.1578

Akhmalia, N. L., Maharta, N., & Suana, W. (2018). Efektivitas Blended Learning Berbasis LMS dengan Model Pembelajaran Inkuiri pada Materi Fluida Statis terhadap Penguasaan Konsep Siswa [The Effectiveness of LMS-Based Blended Learning with Inquiry Learning Models on Static Fluid Material on Students' Mastery of Concepts]. *Jurnal Inovasi Pendidikan Fisika Dan Riset Ilmiah*, *2*(2), 56–64. https://doi.org/10.30599/jipfri.v2i2.299

Antonio, R. P., & Prudente, M. S. (2021). Metacognitive Argument-Driven Inquiry in Teaching Antimicrobial Resistance: Effects on Students' Conceptual Understanding and Argumentation Skills. *Journal of Turkish Science Education*, *18*(2), 192–217. https://doi.org/10.36681/tused.2021.60

Aprilanti, H., Qurbaniah, M., & Muldayanti, N. D. (2016). Identifikasi Miskonsepsi Siswa pada Materi Sistem Eksresi Manusia Kelas XI MIA SMA Negeri 4 Pontianak.[Identification of Students' Misconceptions on the Material of the Human Excretion System for Class XI MIA SMA Negeri 4 Pontianak]. *Jurnal Biologi Edukation*, *3*(2), 63–77.

Arikunto, S. (2009). *Dasar-Dasar Evaluasi Pendidikan (2nd ed.) [Fundamentals of Educational Evaluation (2nd ed.)]*. PT. Bumi Aksara.

Bekiroglu, F. O., & Eskin, H. (2012). Examination of the relationship between engagement in scientific argumentation and conceptual knowledge. *International Journal of Science and Mathematics Education*, *10*(6), 1415–1443. https://doi.org/10.1007/s10763-012-9346-z

Berland, L. K., & Hammer, D. (2012). Framing for scientific argumentation. *Journal of Research in Science Teaching*, *49*(1), 68–94. https://doi.org/10.1002/tea.20446

Bulgren, J. A., Ellis, J. D., & Marquis, J. G. (2014). The Use and Effectiveness of an Argumentation and Evaluation Intervention in Science Classes. *Journal of Science Education and Technology*, *23*(1), 82–97. https://doi.org/10.1007/s10956-013-9452-x

Campbell, N. A., & Reece, J. B. (2010). *Biologi* (W. Hardani & P. Andhika (eds.); 8th ed.). Penerbit Ernangga.

Demircioglu, T., & Ucar, S. (2015). Investigating the effect of argument-driven inquiry in laboratory instruction. *Kuram ve Uygulamada Egitim Bilimleri*, *15*(1), 267–283. https://doi.org/10.12738/estp.2015.1.2324

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

Duschl, R., & Osborne, J. (2002). Supporting and Promoting Argumentation Discourse in Science Education. *Studies in Science Education*, *38*(1), 39–72. https://doi.org/10.1080/03057260208560187

Ekanara, B. (2014). *Keterampilan Argumentasi Siswa SMA (Studi tentang Keterampilan Pembentukan Klaim Mengenai Isu Sosio-Saintifik SMA pada Kelompok Budaya Sunda) [Argumentation Skills of High School Students (Study of Claim Formation Skills Concerning High School Socio-Scientific Issues in Sundanese Cultural Groups)]*. Bandung: Universitas Pendidikan Indonesia.

Ekanara, B., Adisendjaja, Y. H., & Hamdiyati, Y. (2018). Hubungan Kemampuan Penalaran Dengan Keterampilan Argumentasi Siswa Pada Konsep Sistem Pencernaan Melalui Pbl (Problem Based Learning) [The Relationship between Reasoning Ability and Students' Argumentation Skills on the Concept of the Digestive System through PBL (Problem Based Learning)]. *Biodidaktika, Jurnal Biologi Dan Pembelajarannya*, *13*(2). https://doi.org/10.30870/biodidaktika.v13i2.3677

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's Argument Pattern for studying science discourse. *Science Education*, *88*(6), 915–933. https://doi.org/https://doi.org/10.1002/sce.20012

Eymur, G. (2019). The influence of the explicit nature of science instruction embedded in the Argument-Driven Inquiry method in chemistry laboratories on high school students' conceptions about the nature of science. *Chemistry Education Research and Practice*, *20*(1), 17–29. https://doi.org/10.1039/c8rp00135a

Farida, L., Undang, R. & Hasnunidah, N. (2018). Pengaruh penerapan model pembelajaran argumentdriven inquiry (adi) terhadap keterampilan argumentasi siswa smp berdasarkan perbedaan jenis kelamin [The effect of applying the argument driven inquiry (ADI) learning model to the argumentation skills of junior high school students based on gender differences]. *Journal of Physics and Science Learning*, *2*(2), 25-36.

Fatmawati, D. R., Harlita, & Ramli, M. (2018). Meningkatkan Kemampuan Argumentasi Siswa melalui Action Research dengan Fokus Tindakan Think Pair Share. *Proceeding Biology Education Conference*, *15*(1), 253–259.

Förtsch, C., Werner, S., Dorfner, T., von Kotzebue, L., & Neuhaus, B. J. (2017). Effects of Cognitive Activation in Biology Lessons on Students' Situational Interest and Achievement. *Research in Science Education*, *47*(3), 559–578. https://doi.org/10.1007/s11165-016-9517-y

Harianto, Y. (2018). *Analisis pengaruh penguasaan konsep dan literasi kuantitatif terhadap kualitas argumentasi siswa pada materi sistem koordinasi [Analysis of the influence of concept mastery and quantitative literacy on the quality of students' arguments in the coordination system material]*. (Doctoral dissertation, Universitas Pendidikan Indonesia).

Jayawardana, H. B. A. (2015). Pengaruh Penerapan Metode Guided Inquiry terhadap Aktivitas dan Hasil Belajar Biologi Siswa Kelas X SMA N 2 Banguntapan [The Effect of Applying the Guided Inquiry Method to the Activities and Results of Biology Class X Students of SMA N 2 Banguntapan]. *Jurnal BIoedukatika*, *3*(2), 1–8.

Kadayifci, H., & Yalcin-Celik, A. (2016). Implementation of Argument-Driven Inquiry as an Instructional Model in a General Chemistry Laboratory Course. *Science Education International*, *27*(3), 369–390.

Kaunang, S. (2018). Penerapan Pembelajaran Kontekstual Dengan Metode Inkuiri Untuk Meningkatkan Motivasi Dan Hasil Belajar [Application of Contextual Learning with Inquiry Methods to Increase Motivation and Learning Outcomes]. *Aksara: Jurnal Ilmu Pendidikan Nonformal*, *4*(1), 69–78.

Lu, S., Bi, H., & Liu, X. (2018). The effects of explanation-driven inquiry on students' conceptual understanding of redox. *International Journal of Science Education*, *40*(15), 1857-1873.

Lunenburg, F. C. (2010). Communication : The Process , Barriers , And Improving Effectiveness. *Schooling*, *1*(1), 1–11.

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 [Application of the Argument Driven Inquiry (ADI) Model in Improving Students' Arguing Ability on the Concept of Environmental Pollution in Class X SMA Negeri 1 Ciawigebang]. *Quagga : Jurnal Pendidikan Dan Biologi*, *9*(2), 39–45.

McNeill, K. L. (2011). Elementary students' views of explanation, argumentation, and evidence, and their abilities to construct arguments over the school year. *Journal of Research in Science Teaching*, *48*(7), 793–823. https://doi.org/10.1002/tea.20430

Muhiddin, S. M. A. (2015). *Pembelajaran IPA Terpadu Pencemaran Lingkungan dengan Argument-Driven Inquiry untuk Meningkatkan Kemampuan Berargumentasi dan Rasa Ingin Tahu Siswa SMP [Integrated Science Learning on Environmental Pollution with Argument-Driven Inquiry to Improve Argumentative Ability and Curiosity of Junior High School Students.]*. Universitas Pendidikan Indonesia.

Muslim. (2011). Implementasi inovasi pembelajaran ipa berbasis inkuiri untuk menumbuh kembangkan keterampilan proses sains dan sikap ilmiah siswa melaui lesson study [Implementation of inquiry-based science learning innovations to develop students' science process skills and scientific attitudes through lesson study]. *Jurnal Pengajaran MIPA*, *16*(2), 99–108.

Noviyani, M., Kusairi, S., & Amin, M. (2017). Penguasaan Konsep dan Kemampuan Berargumentasi Siswa SMP pada Pembelajaran IPA dengan Inkuiri Berbasis Argumen [Mastery of Concepts and Arguing Ability of Middle School Students in Science Learning with Argument-Based Inquiry]. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *2*(7), 974–978.

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

Paidi, P. (2020). Students' Competence in Cognitive Process and Knowledge in Biology Based on Curriculum Used in Indonesia. *International Journal of Intruction*, *13*(3), 491–510.

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, *14*, 47–61. https://doi.org/10.1016/j.edurev.2015.02.003

Rendhana, I. wayan. (2019). Mengembangkan Keterampilan Abad Ke-21 Dalam Pembelajaran Kimia [Developing 21st Century Skills in Chemistry Learning]. *Jurnal Inovasi Pendidikan Kimia*, *13*(1), 2239–2253. https://doi.org/https://doi.org/10.15294/jipk.v13i1.17824

Ruhulessin, S., Ratumanan, T. G., & Tamalene, H. (2019). Perbedaan Hasil Belajar Siswa Kelas X Sma Menggunakan Model Pembelajaran Kooperatif Tipe Student Facilitator and Explaining (Sfe) Dan Model Pembelajaran Konvensional Pada Materi Trigonometri [Differences in Student Facilitator and Explaining (Sfe) Class X High School Cooperative Learning Models and Conventional Learning Models in Trigonometry Material]. *JUPITEK: Jurnal Pendidikan Matematika*, *2*(1), 1–6. https://doi.org/10.30598/jupitekvol2iss1pp1-6

Safira, C. A., Hasnunidah, N., & Sikumbang, D. (2018). Pengaruh Model Pembelajaran Argument-Driven Inquiry (ADI) terhadap Keterampilan Argumentasi Siswa Berkemampuan Akademik Berbeda [The Effect of the Argument-Driven Inquiry (ADI) Learning Model on the Argumentation Skills of Students with Different Academic Abilities]. *Assimilation: Indonesian Journal of Biology Education*, *1*(2), 46–51. https://doi.org/10.17509/aijbe.v1i2.13046

Salsabila, E. R., Wijaya, A. F. C., Winarno, N., & Hanif, S. (2019). Using argument-driven inquiry to promote students' concept mastery in learning global warming. *Journal of Physics: Conference Series*, *1280*(3). https://doi.org/10.1088/1742-6596/1280/3/032052

Sampson, V., & Gerbino, F. (2010). Two Instructional Models That Teachers Can Use to Promote & Support Scientific Argumentation in the Biology Classroom. *The American Biology Teacher*, *72*(7), 427–431. https://doi.org/10.1525/abt.2010.72.7.7

Sampson, V., & Gleim, L. (2009). in Biology ARTICLE Argument-Driven Inquiry To Promote AB ? of the Understanding Important Concepts & Practices O ? ... students need THE AMERICAN ARGUMENT-DRIVEN. *October*, *71*(8), 465–472.

Sampson, V., Enderle, P., Gleim, L., Grooms, J., Hester, M., Shoutherland, S., & Wilson, K. (2014). *Argument-Driven Inquiry in Biology: Lab Investigations for Grades 9-12* (K. Reinburg, W. Rubin, A. Cooke, A. O'Brien, & A. America (eds.)). National Science Teacher Associations. https://books.google.co.id/books?id=jONrBgAAQBAJ&pg=PA24&lpg=PA24&dq=Writing+to+Learn+by+Learning+to+Write+During+the+School+Science+Laboratory:+Helping+Middle+and+High+School+Students+Develop+Argumentative+Writing+Skills+as+They+Learn+Core+Ideas&source=b

Saracaloglu, A. S., Aktamis, H., & Delioglu, Y. (2011). The impact of the development of prospective teachers' critical thinking skills on scientific argumentation training and on their ability to construct an argument. *Journal of Baltic Science Education*, *10*(4), 243–260.

Sari, R. A., Musthafa, B., & Yusuf, F. N. (2021). Pembelajaran Argument Driven Inquiry Pada Materi Suhu dan Kalor Untuk Meningkatkan Kemampuan Argumentasi Ilmiah Siswa. [Argument Driven Inquiry Learning on Temperature and Heat Materials to Improve Students ' Scientific Argumentation Ability]. *Jurnal Penelitian Pendidikan*, *21*(2), 88–97. https://doi.org/10.17509/jpp.v21i2.37134

Shanmugavelu, G., Parasuraman, B., Ariffin, K., Kannan, B., & Vadivelu, M. (2020). Inquiry Method in the Teaching and Learning Process. *Shanlax: International Journal of Education*, *8*(3), 6–9. https://doi.org/10.34293/ education.v8i3.2396

Sumiyati, S., Yeni, L. F., & Marlina, R. (2016). *Pengaruh Model Inkuiri Terhadap Hasil Belajar Siswa Pada Sub Materi Spermatophyta Kelas X [The Influence of the Inquiry Model on Student Learning Outcomes in Class X Spermatophyta Sub Material]*. (Doctoral dissertation, Tanjungpura University).

Supriyati, E., Setyawati, O. I., Purwanti, D. Y., Salsabila, L. S., & Prayitno, B. A. (2018). Profil Keterampilan Berpikir Kritis Siswa SMA Swasta di Sragen Pada Materi Sistem Reproduksi [Profile of Critical Thinking Skills of Private High School Students in Sragen on Reproductive System Material]. *Bioedukasi: Jurnal Pendidikan Biologi*, *11*(2), 74–80.

Syerliana, L., Muslim, & Setiawan, W. (2018). Argumentation skill profile using "toulmin Argumentation Pattern" analysis of high school student at Subang on topic hydrostatic pressure. *Journal of Physics: Conference Series*, *1013*(1). https://doi.org/10.1088/1742-6596/1013/1/012031

Ubaque Casallas, D. F., & Pinilla Castellanos, F. S. (2016). Argumentation skills: A peer assessment approach to discussions in the EFL classroom. *Profile Issues in TeachersProfessional Development*, *18*(2), 111-123. https://doi.org/10.15446/profile.v18n2.53314

Utomo, Y. S., Ashadi, & Sarwanto. (2019). Argumentation Skills Profile on 8th Grade Students using Toulmin's Argument Pattern on Controversial topic. *Journal of Physics: Conference Series*, *1233*(1), 0–9. https://doi.org/10.1088/1742-6596/1233/1/012095

Walker, J. P., Sampson, V., & Zimmerman, C. O. (2011). Argument-driven inquiry: An introduction to a new instructional model for use in undergraduate chemistry labs. *Journal of Chemical Education*, *88*(8), 1048–1056. https://doi.org/10.1021/ed100622h

Widodo, A. (2006). Taksonomi Bloom dan Pengembangan Butir Soal [Bloom's Taxonomy and Item Development]. *Buletin Puspendik*, *3*(2), 18–29.

Widodo, A. (2021). *Pembelajaran Ilmu Pengetahuan Alam: Dasar-Dasar Untuk Praktik [Natural Science Learning: Fundamentals For Practice]* (M. Iriany (ed.); 1st ed.). UPI PRESS.

Yolanda, S. E., Gunawan, G., & Sutrio, S. (2019). Pengaruh Model Pembelajaran Inkuiri Terbimbing Berbantuan Video Kontekstual Terhadap Penguasaan Konsep Fisika Peserta Didik [The Effect of Contextual Video Assisted Guided Inquiry Learning Models on Students' Mastery of Physics Concepts]. *Jurnal Pendidikan Fisika Dan Teknologi*, *5*(2), 341–347. https://doi.org/10.29303/jpft.v5i2.1393.