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Effectiveness of argument-driven inquiry (ADI) on students' concept mastery and argumentation skills in reproductive system

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ABSTRACT

This study aims to determine the effect of the Argument-Driven Inquiry (ADI) learning model application on the concepts mastery and argumentation skills of high school students on reproductive system material. The research method used quasi-experimental and non-equivalent control group design. The sample of this research were second-grade high school MIPA students in one of the public high schools in Bandung, which consists of 30 students in the experimental class and 33 students in the control class. The sample was taken by using the purposive sampling technique. The instruments used consisted of a concept mastery test in the form of multiple choices, an argumentation ability test in the form of an essay, and questionnaire of students' responses to the ADI model. The results showed that the application of the ADI learning model significantly affected the students' concepts mastery on reproductive system material in the experimental class compared to the control class, especially in the cognitive aspects of C3 (applying). The results also show that the application of the ADI learning model significantly affects the ability of argumentation, especially on the warrant component. Student response data shows that students respond very well to the application of the ADI learning model. Therefore, the ADI learning model is recommended for biology teachers to improve students' concepts mastery mastery and argumentation skills in other biological materials.

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INTRODUCTION

The 21st century is an era of globalization marked by the rapid development of technology and information. Along with the development of these two things, superior and quality human resources are needed, have high thinking skills, and can compete in the global era (Astira et al., 2019). 21st-century skills that everyone must master include critical thinking and problem-solving, creativity and innovation, collaboration, and communication (Ristanto, et al., 2020; Harahap, et al., 2020; Redhana, 2019). US-based Partnership for 21st Century Skills (P21, 2008) identified the competencies needed in 21st century is "The 4Cs", communication, collaboration, critical thinking, and creativity. These competencies are important to be taught to students in the context of core subject areas and 21st century themes (Zubaidah, 2016).One skill that is no less important in this century is communication skills.

According to Redhana (2019), 21st-century skills will be effective through education . In the world of education, soft skills are an aspect that students need in this century. One of these abilities is the ability to argue, which is included in communication skills (American Association of Colleges and Teacher Education, 2013). The ability of argumentation is important to concepts mastery of students because it's related to their knowledge and thinking skills (Bekiroglu & Eskin, 2012). Through argumentation activities, students can apply the scientific knowledge they have learned in everyday life with connecting material concepts accompanied by evidence to draw conclussion (Bulgren et al., 2014). The ability of students to reconnect the material obtained during the learning process shows the level of concepts mastery of student, and good conceptual mastery will be able to improve students' argumentative skills well (Noviyani et al., 2017).

The 2013 curriculum has accommodated 21st-century skills, both in terms of content standards, processes, and assessment standards, however, the school environment often does not support students to argue (Ekanara et al., 2018). In reality, in the field, according to Nazliah & Saragih (2019), learning carried out by teachers still uses conventional learning, namely the lecture method. This learning is less helpful for students to develop 21st-century students' skills, especially argumentation skills.

The results of previous studies show that the students' argumentation skills are still low, which is still at the basic level (Ekanara et al., 2018; Syerliana et al., 2018; Utomo et al., 2019). This is supported by research conducted by Mahardika et al. (2015) on 21 high school students, the results obtained were only seven people who had high argumentative skills. Based on this statement, it is necessary to have learning activities that can facilitate students to develop 21st-century skills, especially argumentation skills.

One solution to problems solving in learning activities requires model or strategy that involves students actively in constructing knowledge (Tendrita et al., 2017). A learning model that can improve argumentation skills is the Argument-Driven Inquiry (ADI) developed by Sampson & Gleim (2009). The ADI model is considered an effective model in improving communication skills and developing students' knowledge construction skills (Demircioglu & Ucar, 2015). ADI emphasizes learning activities in the form of knowledge construction and validation through inquiry activities by emphasizing the important role of argumentation activities (Sampson & Gleim, 2009; Andriani, 2015b).

The ADI model was developed to help students understand important concepts and practices in Biology (Sampson & Gleim, 2009). The current syntax of the ADI model consists 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.The material in Biology has many concepts directly related to everyday life so that it needs to be understood by students. However, there are still some students who experience misconceptions, one of which is in the reproductive system material (Ardiyanti & Utami, 2017). This is because the learning that is carried out tends to be theoretical and rarely relates it to social problems in the environment causing a lot of information about reproduction to be inaccurate (Lu et al.. 2018; Nazliah & Saragih, 2019).

Looking at the previous research conducted by Amelia et al. (2018) and Salsabila et al. (2019), the ADI learning model can improve students' argumentation skills and conceptual mastery, especially on

environmental change, namely global warming. Likewise with the results of Andriani's research (2015) which applies the ADI model to integrated science learning which shows an increase in students' mastery of concepts and argumentation skills. However, there is still little application of the ADI learning model to reproductive system materials that have the characteristics of abstract material so that it is difficult for students to understand. Especially regarding the sub-material of diseases or disorders in the human reproductive system, which so far the teacher has always used the lecture method in the learning process. The teacher only conveys the definition of the disease and what causes the disease or disorder without relating it to everyday life, so that when faced with problems in the health of the reproductive system, students are still confused in solving these problems. One example is the issue between e-cigarettes and tobacco cigarettes, which has more impact on the health of the reproductive system. The answer to this issue will emerge debate that stimulates students to argue. Therefore, based on this explanation, the material on the reproductive system with sub-subjects of reproductive system diseases/disorders is deemed applicable with the ADI learning model.

Thus, it is necessary to research the effect of the application of the ADI learning model on the mastery of concepts and argumentation skills of high school students, especially on reproductive system material. However, in 2020, there was an outbreak of the COVID-19 virus, including the country of Indonesia. During this pandemic period, face-to-face teaching and learning activities were shifted to online one. Due to conditions that cannot be possible, the research conducted by the author must be done online, so that the ADI learning model is modified into an online form.

METHODS

Research Design

The research method used in this study was a quasi-experimental with nonequivalent control group design which refers to Sugiyono (2009). This design was chosen because it supported researchers to collect data on differences in conceptual mastery and argumentation skills between the experimental class and the control class that was not randomly selected. The research design mechanism used can be seen in Table 1.

Table 1
Research Design

Class	Pre-test	Treatment	Post-test
Experiment	O1	x	O2
Control	O1	y	O2

O1 : Pre-test to measure the mastery of concepts and argumentation skills
O2 : Post-test to measure the mastery of concepts and argumentation skills
x : learning uses ADI
y : learning uses 5e learning cycle

Population and Samples

The population used in this study were all class XI MIPA high school students in one of the public high schools in Bandung City, Indonesia in the even semester of the 2019/2020 school year. The sample in this study was two classes from the entire population with a total number of 63 students. The sample selection technique used was purposive.

Instrument

The instrument used in this study consisted of a test instrument, namely a concept mastery test in the form of multiple-choice questions of 20 questions in the cognitive domain from 25% of C1, 45% of C2, 15% of C3, to 15% of C4, and a written argumentation ability test in the form of essay questions consisting of five questions. Argumentation ability tests to measure students' skills for writing scientific argumentation that is composed of four components, namely the claim, data, warrants, and backing (Simon, 2008) with indicator that was developed by Sampson & Gerbino (2010). There are four indicators of argumentation skills which can be seen in Table 2. Students' argumentation skills can be said to be good and have quality arguments if the four indicators can be met.In addition to the test instrument, non-test instruments were also used in the form of student response questionnaires to learning using the ADI model. This instrument contain of 15 questions or statements that are measured using Likert scale. In the questionnaire, there are positive and negative statements that have different

score on each Likert scale responses which are presentes in Table 3.Positive statements that have the highest score are categorized as "Strongly Agree", whereas negative statements that have the lowest scores are categorized as "Strongly Disagree". After that, the score for each statement is calculated using the formula and then the average of each aspect is calculated. The formula for calculating the score used is as follows.

$$\frac{Score\ obtained}{Maximal\ score} \times 100\%$$

Then the calculation results are interpreted based on the category of questionnaire percentage gain (Table 4) as follows. The greater the percentage obtained, the better the response to learning using the ADI model.

Table 2
Indicator of Argumentation Skills.

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

Table 3.
Score of Statements on Students Response Quesionnaire

Response	Score	
	Positive Statement	Negative Statement
Strongly Agree	4	1
Agree	3	2
Disagree	2	3
Strongly Disagree	1	4

Table 4.
Category of Questionnaire Percentage

Percentage	Category
81% - 100%	Very Good
61% - 80%	Good
41% - 60%	Enough
21% - 40%	Poorly
0% - 20%	Very Poorly

The material used in the experimental class learning using ADI and the control class using the 5e learning cycle is the same, namely about the sub-discussion of the impact of promiscuity, diseases/disorders in human reproductive organs, and human reproductive system technology.

Validity and Reliability

The test items must be proven valid and the reliability alignment is seen before being used in research. In this study, test the validity and reliability of the questions using program ANATES 4.10 ver which was interpreted base on the validity and reliability index of the questions according to Arikunto (2012) (Table 5).

Table 5
Index of Validity and Reliability

Scale	Index
0.00 – 0.19	Very low
0.20 – 0.39	Low
0.40 – 0.59	Enough
0.60 – 0.79	High
0.80 – 1.00	Very High

Procedure

The research preparation stage begins with a preliminary study, namely identifying the problem to be carried out in the research. In the next stage, instruments began to be made at this stage. The instrument used consisted of a conceptual reasoning ability test, an argumentation ability test, and a student response questionnaire to the ADI learning model. After that, a trial was conducted on students who had studied the material raised in the research. The results of the trial were then tested for validity and reliability. In the first week of the research, students were given initial test questions in the form of an argumentation ability test and a concept mastery test in the experimental class and control class through Google Form media. In the second week with the same material discussed, the experimental class applied the ADI model learning, while the control class used the 5e learning cycle. Learning in both classes is equally carried out in Google Classroom. After finishing learning, both classes were given final test questions in the experimental class and the control class. The questions tested are the same as the initial test questions. Just like the initial test, the final test is given through Google Form media. Specifically for the experimental class, a student response questionnaire was given to the implementation of the ADI learning model in the experimental class after the final test was carried out. Questionnaires are given through Google Form media, integrated with special final test questions in the experimental class.

Data Analysis Techniques

Data analysis on the conceptual mastery test and argumentation skills used statistical tests using SPSS version 26 software to see that there were significant differences in the pretest and posttest between the experimental and the control class. Then for questionnaire data on students' responses to ADI model learning were analyzed using questionnaire percentage categorization to find out how students responded to learning activities based on the percentage results of each indicator being asked. The material used in the experimental class learning using ADI and the control class using the 5e learning cycle is the same, namely about the sub-discussion of the impact of promiscuity, diseases/disorders in human reproductive organs, and human reproductive system technology.

RESULTS AND DISCUSSION

Mastery of Concepts

Students' mastery of concepts is measured before and after learning begins, both in the experimental and the control class. Measurements using the pretest and posttest were then compared to the average value. The average pretest, posttest, and value categories are presented in Table 6.

Table 6

Recapitulation of Mean Value of Pretest, Posttest, Category of Concept Mastery Test Value

Data	Pretest		Posttest	
	Experiment	Control	Experiment	Control
N	30.00	33.00	30.00	30.00
Mean	58.33	59.55	82.50	70.15
St. Deviation	18.07	16.38	12.02	11.76
Max	90.00	80.00	95.00	85.00
Min	20.00	15.00	50.00	40.00
Category	**Fair**	**Fair**	**Very high**	**Very high**

Table 7

Recapitulation of the Statistical Test Results of the Concept Mastery Test

Test	Pretest		Posttest	
	Experiment	Control	Experiment	Control
Kolmogorov-Smirnov	0.200	0.003	0.000	0.001
Levene	0.700		0.896	
Mann Whitney U	0.673		0.000	

Based on these results, the concept mastery pretest in the two classes can be said to be the same or not much different, that is, both are categorized as sufficient. This is evidenced by the results of different tests presented in Table 7, showing that there was no significant difference in the pretest between the

experimental class and the control class. However, after the treatment, namely the experimental class using the ADI model and the control class using the 5e learning cycle, the post-test results of the two classes had a significant difference. The mastery of the experimental class concept was higher than the control class, so it could be stated that the use of the ADI learning model affected the students' concept mastery of the experimental class. This is in line with the results of research conducted by Salsabila et al. (2019) and Andriani (2015b) that the value of the experimental class mastery of concepts has increased better than the control class, so it can be concluded that the use of the ADI learning model can further improve students' mastery of concepts.

There is difference in conceptual mastery between the two classes so that it can improve concept mastery and influenced by the stages in the ADI learning model. During the learning process using the ADI model, the activities of making tentative arguments and argumentation sessions are factors that affect students' conceptual mastery. The ADI learning model, especially at the argumentation session stage, provides space for students to explore and stimulate thinking skills that need to be mastered (Putra et al ., 2014). In this learning model, students are trained to make arguments, so that through this activity their conceptual mastery is emphasized. When the discussion was implicit and reflective, it was seen that the experimental class students tended to be more active in the discussion process than the control class students during the discussion session at the Explain stage in the learning cycle 5e model. This is in line with research conducted by Andriani (2015b).

The advantages of learning using the ADI model in the experimental class provides students the opportunity to practice problems solving by making observations or investigations, designing their investigations, and making arguments that can help them better understand what is being learned (Rahayu et al., 2019).The combination of activities carried out in the ADI learning model helps students understand the concept (Sampson, 2014). Especially at the stage of making tentative arguments and argumentation sessions that emphasize understanding their concepts to be associated with the arguments made, because to build a good argument students need good mastery of knowledge of material content (Marhamah et al., 2017). Thus this statement supports the results obtained that the ADI learning model improves students' concepts mastery in the experimental class compared to the control class.

Written Argumentation Capability

The ability of students' written argumentation, as well as mastery of concepts, is measured before and after learning begins, both in the experimental class and in the control class. Measurements using the pretest and posttest were then compared to the average value. The average pretest, posttest, and value categories are presented in Table 4.

Based on these results, the students' written argumentation skills in the experimental class and the control class did not have a significant difference. This is evidenced by the results of the pretest difference test which are presented in Table 5. It can be seen that both in the experimental and the control class, their argumentation skills are in a low category. Table 4. However, after the treatment, when measured again using the posttest, the argumentation abilities of the experimental class students and the control class has a significant difference as evidenced by the results of the posttest difference test in Table 5, so it can be said that the application of the ADI learning model influences students' argumentation skills.

Table 4

Recapitulation of the mean value of the pretest, posttest, category of written argumentation ability test values

Data	Pretest		Posttest	
	Experiment	Control	Experiment	Control
N	30.00	33.00	30.00	30.00
Mean	39.58	33.71	66.00	54.32
St. Deviation	12.88	14.65	14.47	12.25
Max	70.00	65.00	90.00	80.00
Min	20.00	5.00	37.50	30.00
Category	**Low**	**Low**	**High**	**Fair**

Table 5
Recapitulation of Written Argumentation Ability Test Results

Test	Pretest		Posttest	
	Experiment	Control	Experiment	Control
Kolmogorov-Smirnov	0.017	0.106	0.130	0.200
Levene	0.525		0.335	
Mann Whitney U	Mann Whitney U		Independent Sample T	
	0.080		0.001	

When compared to the average score of the argumentation ability, the experimental class students is higher than the control class, and this value has increased and entered into the high category. This is in line with the results of research by Demircioğlu & Uçar (2012) that the ADI learning model has a significant effect on argumentation skills, as evidenced by an increase in the argumentation ability of the experimental class compared to the control class that does not use ADI.

The same thing was stated by Marhamah et al. (2017) that the ADI learning model can improve students 'argumentation skills because the ADI model supports students to develop argumentative skills and the quality of students' arguments. The difference that occurs in the experimental class using the ADI model and the control class using the 5e learning cycle can be caused because there are several stages of the ADI model that are not found in the 5e learning cycle, these stages are making tentative arguments and argumentation sessions (Marhamah et al., 2017). Through these two stages, students are helped to develop scientific thinking and critical thinking habits to solve problems with argumentation activities (Marhamah et al., 2017; Farida et al., 2018). Sampson & Gleim (2009) describe, the application of the ADI learning model in the classroom learning process has a positive impact, especially in creating an active and conducive classroom atmosphere for students to present their arguments, for example by debating activities. Therefore, the steps in this model can create a classroom atmosphere that facilitates the development of students' argumentation skills.

Their ability to produce an argument is better after implementation. Thus, the ADI learning model can significantly improve students' ability to provide evidence and strong reasons to support their claims, so that students can make good and correct arguments (Walker et al., 2011).

Comparison of Value Categories for Each Cognitive Aspect of Concept Mastery

Mastery of the concepts referred in this study is the cognitive dimension of Bloom's revised taxonomy which is limited to the cognitive aspects of C1 (remembering), C2 (understanding), C3 (applying), and C4 (analyzing). The comparison of the difference in the average score of each cognitive aspect can be seen from the score category for each cognitive aspect. The value categories refer to the cognitive level categories according to Arikunto (2012) with the very high, high, moderate, low, or very low categories. The value categories for each cognitive aspect of concept mastery are presented in Figure 2.

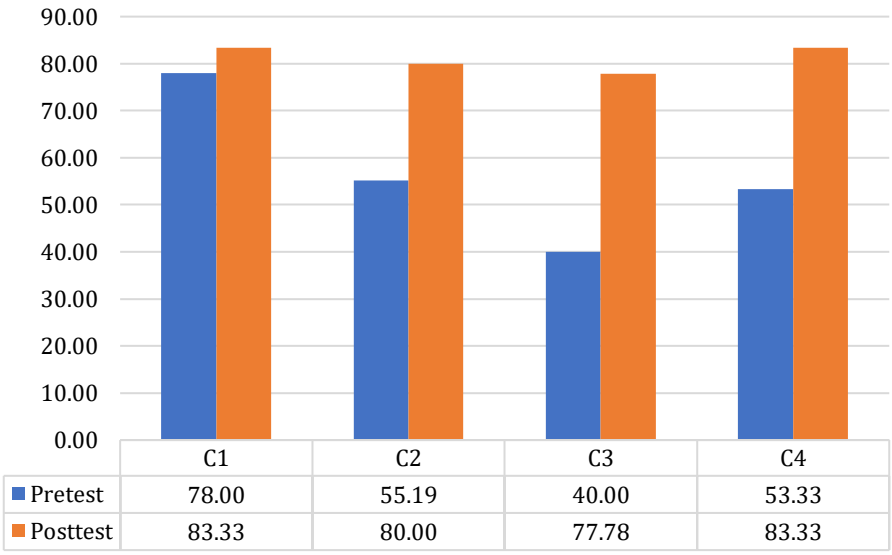


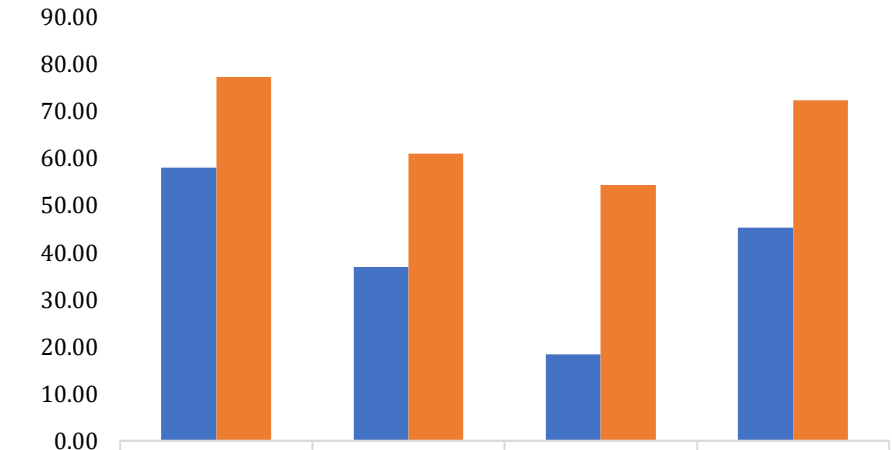
Figure 2. Recapitulation of Average Value Categorization of Each Cognitive Aspect of Concept Mastery in Experiment Class

Based on these results it can be seen that the highest cognitive aspects of both the average value of the pretest and the average value posttest ie on cognitive aspects C1 (given) and on the value posttest categorized as very high. In the understanding aspect (C2) has a high average posttest score. These results are supported by research conducted by Andriani (2015a; 2015b) that the ADI learning model helps students to improve conceptual understanding. Then in the C3 aspect which initially had a low average value, after the treatment, this aspect experienced a significant increase, so that the average value obtained was categorized as high. This is because, in the ADI learning model, students are required to make an answer in the discourse in the form of an argument so that students are accustomed to applying their understanding and are accustomed to making warrants in an argument from the problem. (Andriani, 2015b).

The analyzing aspect (C4) also experienced a quite large difference between the pretest and posttest. This is because, in the argumentation session, students carry out questioning activities and review the arguments presented. Both of these according to the taxonomy of Anderson and Krathwohl (2010) included in tiers analyses (analyzing), so it is possible to analyze aspects of their activity increased after an argument on the model ADI.

Comparison of Value Categories for Each Argument Component

The comparison of the average value of each component of the argumentation ability of students in the experimental class can be seen from the category of the average score of each component of the argumentation ability. Just as the mean score for each cognitive aspect of conceptualization, the mean score for each component of the argumentation was categorized by category. The value categories of each argument component are shown in Figure 3.



	Claim	Data	Warrant	Backing
Pretest	58.00	37.00	18.33	45.33
Posttest	77.33	61.00	54.33	72.33

Figure 3. Recapitulation of the mean value categorization of each component of the argument ability of the experimental class

Based on these results it can be seen that the value of each argument component in the experimental class students after the implementation of ADI model learning has increased. This increase can be seen from the differences obtained from each component. The claim component in the posttest results has the highest average score with a very high category compared to other components. According to Erduran et al. (2012), the claim component most often arises because claims are only an idea, statement, hypothesis, or opinion of an event or phenomenon that is not supported by evidence and reasons. In the pre-treatment data component, the student's ability to make the data component was categorized as low, after the ADI model treatment, the students' ability in the experimental class in making the data component increased into a high category.

The warrant component has the lowest average score on both the pretest and posttest. However, the warrant component has a much bigger difference between its pretest and posttest results compared to other components. This result is consistent with what was stated by Sampson et al., (2011) and Walker et al. (2011) stated that the tentative argument-making stage helps students improve their

understanding of how good quality arguments support claims that consist of a relationship between evidence and claims. What is meant by good argument quality in this context is that an argument consists of four components, claims, data, warrants, and backings and the four components are interconnected (Sampson & Gerbino, 2010).

The backing component has the second-highest average value compared to other components. At the time of the pretest, the backing component was included in the sufficient category, so it could be said that the students' ability to provide support for their arguments was still in the sufficient category. However, at the average posttest score, the backing component increases so that it belongs to the high category. This is because students in the ADI learning model are required to provide support for their arguments so that they can be used to argue or defend arguments during the argumentation session.

The ADI learning model itself has the potential to help students build qualified scientific arguments through argumentation sessions and make reports on the results of investigations that develop students' ability to make valid conclusions based on evidence from investigations (Mutia, 2015). Compared to the control class, students tend to only present their findings, and the class conditions are less active in conducting questions and answers so that there are no argumentative activities that occur in the class that hone students' ability to make arguments. This difference is what distinguishes the implementation between the ADI model and the control class model. At the ADI model stage, students must relate their findings to previous information (Farida et al., 2018). The previous information in question is in the form of students' initial knowledge of the concepts that have been mastered by them. This becomes an influential aspect in the level of students' ability to argue (Manz, 2015; Noviyani et al., 2017).

Student Response to Learning Model ADI

Student response data to learning using ADI was obtained from a questionnaire given to experimental class students after doing ADI learning. The overall results of the student response questionnaire data showed that almost all students in the experimental class responded very well to the ADI model learning that had been implemented. Thus, it means that students in the experimental class stated that they were interested in the application of the ADI learning model in learning material on the reproductive system. Based on the response questionnaire, students in the experimental class felt they were more courageous in expressing their opinions. They also feel that learning with the ADI model trains them in making good scientific arguments, which do not only contain opinions or claims but also with evidence and data that can support their arguments to be valid. Students also stated that they were interested in learning the ADI model rather than just reading textbooks or power points delivered by the teacher.

CONCLUSION

Overall, the ADI learning model has an influence on the students' concepts mastery and argumentation skills on the reproductive system material. This is evidenced by the results of the post-test difference test both on the conceptual mastery data and the ability to argue that there are significant differences. This model can also improve every cognitive aspect of concept mastery by 58% with the C3 aspect experiencing greater differences between the pretest and posttest than other aspects, as well as increasing each component of the argument by 44% with warrant components which have greater differences between pretest and posttest than other components.

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