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Submission date: 02-Aug-2022 08:00PM (UTC+0700)
Submission ID: 1878080194
File name: Astuti_Muh_Amin_dkk_23-35.pdf (455.4K)
Word count: 6185
Character count: 36699

Edubiotik: Jurnal Pendidikan, Biologi dan Terapan
ISSN 2528-679X (print), ISSN 2597-9833 (online)
Vol. 7, No. 01, February 2022, pp. 23 – 35
Available online at:
http://ejurnal.budiutomomalang.ac.id/index.php/edubiotik

Research Article

OPEN ACCESS

Conceptual knowledge and argumentation skills of biology students in animal physiology courses

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Article Information
Submitted: 2021-08-31
Accepted: 2022-07-21
Published: 2022-07-21

ABSTRACT

Argumentation facilitates students' cognitive activities as they construct scientific knowledge. Studies related to the relationship between conceptual knowledge and argumentation skills in biology learning, especially in animal physiology courses, are still rarely carried out. The primary aim of this study was to determine the correlation between students' mastery of biology concepts and argumentation skills. A correlational research design was employed. The research sample consisted of 106 fourth semester Biology Education students. The students' mastery of biology concepts and argumentation skills were evaluated using valid and reliable instruments. Conceptual knowledge measured in this study refers to students' ability to explain their responses to essay tests on cognitive concepts. Besides, this study also assessed students' ability to participate in scientific debates and compose written arguments based on the Toulmin Argumentation Pattern (TAP) framework. This study indicates an association between students' grasp of biology concepts and their argumentation skills in the ADI class. The regression equation derived from the data analysis is $y = 0.605x + 39.05$ with a reliability value of 0.179. Meanwhile, there is no strong correlation between conceptual knowledge and argumentation skills in RQA, ADI-integrated RQA, or traditional classes. This can be influenced by a variety of factors, including students' inability to adapt and adjust rapidly to the steps introduced into the learning models. Improving argumentation quality can be accomplished through the use of active and innovative learning models or strategies.

Keywords: ADI; argumentation skills; conceptual knowledge

Publisher
Biology Education Department
IKIP Budi Utomo, Malang, Indonesia

How to Cite
Amin, A., Adiansyah, R., & Hujjatusnaini, N. (2022). Conceptual knowledge and argumentation skills of biology students in animal physiology courses. *Edubiotik : Jurnal Pendidikan, Biologi Dan Terapan*, *7*(01), 23-35. https://doi.org/10.33503/ebio.v7i01.1380

INTRODUCTION

The quality of students' argumentation demonstrates their reasoning abilities, which include knowledge and insight (Abduh et al., 2019; Sumarni et al., 2017). Students will have a solid argument if it is accompanied by a strong theoretical foundation (Nur'aini et al., 2019). Argumentation aids students'

cognitive activities associated with the acquisition of scientific knowledge (Vera et al., 2021). Argumentation skills significantly aid students in assessing information and then evaluating it in order to generate a quality argument (Roviati & Widodo, 2019). Argumentation is advantageous in science because it is a dialogical and interactive process through which students can practice developing skills, increasing conceptual understanding, and improving scientific performance (Faize et al., 2018).

Argumentation requires students to provide statements accompanied by reasons that are relevant to the problem and theory (Anita et al., 2019; Imaniar & Astutik, 2019). Argumentation plays a significant role in students' acquisition of scientific concepts (Heng et al., 2014). The extent to which students comprehend and master concepts is one of the factors that influences the quality of their argumentation (Wahdan et al., 2017). Students can develop strong argumentation skills if they have adequate conceptual knowledge (Rahmadhani et al., 2020).

Concepts are needed in argumentation, as the formulation of claims and the submission of reasons, including data, justification, and support, must be founded on sound concepts (Simbolon et al., 2020). Students' involvement in the argumentation process can result in increased conceptual mastery, as students must understand the content well in order to construct arguments (Ogan-Bekiroglu & Eskin, 2012). Students' ability to interpret concepts correctly enables them to develop strong scientific argumentation skills (Anwar et al., 2019).

Studies related to the relationship between conceptual knowledge and argumentation skills are still not widely carried out, especially in animal physiology courses. The results of the preliminary study conducted by the researcher showed that the empowerment of argumentation skills and its measurement is still rarely carried out by lecturers in learning interactions in the classroom. Students find it difficult to develop quality arguments in class discussions. Quality arguments are accompanied by claims of evidence and a strong theoretical basis (Probosari et al., 2016). Students are not used to doing argumentative practice in the learning process in class. The involvement of students in science as an argumentative practice can encourage reflection and evaluation of evidence (Bathgate et al., 2015).

RQA, ADI, and ADI-Integrated RQA are all active and innovative learning strategies that can be utilized to increase students' comprehension of topics and argumentation skills. The application of the RQA learning model has the potential to support the development of students' conceptual knowledge. Students' reading habits are continually honed in RQA through reading activities and the creation of summaries of reading material related to class topics, as well as through the creation of questions, the answering of questions, and the making of inferences (Amin, 2020). The questioning and answering phase in RQA builds students' confidence (Darmayanti, 2015), which is necessary when participating in interactive learning discussions. Students who have a healthy sense of self-confidence will dare to make arguments based on their beliefs (Amin, 2020). This way, students can develop their critical thinking abilities and produce persuasive arguments.

Previous research has demonstrated that ADI can help students improve their argumentation skills (Dwiretno & Setyarsih, 2018; Kadayifci & Celik, 2016). The ADI model's application can help students develop a discipline for producing high-quality arguments (Sampson et al., 2011). Additionally, ADI is highly effective at increasing students' conceptual knowledge (Hidayat et al., 2018; Prastio & Hasnunidah, 2019). This study is different from previous research, because in research the relationship between conceptual knowledge and and argumentation skills was studied through four different learning designs in animal physiology lectures. Studies related to this are still rarely done so that researchers consider this research important to do.

The purpose of the present study was to examine the association between the conceptual knowledge and argumentation skills of Biology students. This study is expected to shed light on the relationship between conceptual knowledge and argumentation skills in classes taught using the RQA, ADI, ADI-Integrated RQA, and traditional learning models. It is anticipated that the active and innovative learning strategies can promote the conceptual knowledge and argumentation skills among students. The findings in this study are expected to provide information regarding the contribution of conceptual knowledge to argumentation skills through four different learning designs. The hope is that it can play a positive role for educators in efforts to improve the quality and outcomes of student learning outcomes, especially for prospective biology teachers.

RESEARCH METHODS

A correlational research design was employed to reveal the relationship between students' conceptual knowledge, as the predictor, and students' argumentation skills as the criterion. The study population comprised all Biology Education students from Maros and Makassar in South Sulawesi, Indonesia. The research sample consisted of 106 fourth semester Biology Education students who were enrolled in Animal Physiology courses. A random sampling technique was used to select the sample. Homogeneity testing was performed using a placement test. The study was conducted between February and July at UIN Alauddin Makassar dan Universitas Muslim Maros.

The research instruments were developed to assess the participants' conceptual knowledge and argumentation skills. Conceptual knowledge measured in this study was the ability of students to present answers to essay questions, which involve concepts in the Anderson and Krathwohl's cognitive dimensions, including remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6). Instruments for conceptual knowledge and argumentation skills had been subjected to expert and empirical validation prior to their use. Validation and reliability tests established the validity and reliability of the instruments.

The argumentation skills assessed in this study were students' ability to engage in scientific argumentation and compose written arguments using Toulmin's Argumentation Pattern (TAP) framework. Table 1 illustrates the TAP-based assessment of argumentation skills.

Table 1. TAP-Based Assessment of Argumentation Skills

Level	Criteria
5	Argumentation contains a lengthy debate with multiple distinct rebuttals.
4	Argumentation demonstrates an argument with a clear refutation and contains multiple claims and counterclaims.
3	Argumentation consists of allegations and counterclaims presented in a series.
2	Argumentation includes arguments from one claim or counterclaim with evidence, guarantors, or supporters, but not rebuttals.
1	Argumentation presents one simple claim against a counterclaim or one claim against another.

Source: (Amin et al., 2021; Osborne et al., 2004)

This study began with the design and development of instructional materials and research instruments. Prior to their use, the instruments for conceptual knowledge and argumentation skills underwent validation. Validation by experts consisted of two components: content validity and construct validity. Three educational evaluation experts (lecturers), an expert in the development of learning tools, and a biologist were invited to perform expert validation. Empirical validation was conducted on 50 sixth semester students from the Department of Biology Educatio of UIN Alauddin Makassar. A pretest was used to collect data.

Experts' construct validation results for the conceptual knowledge test obtained a mean score of 3.74 (very valid category). The instrument's validity test was done by performing confirmatory factor analysis. It obtained a factor weighting value of > 0.3 and a T-value of ± 1.96 (all conceptual knowlege instrument items were declared valid). The Alpha Cronbach's coefficient related to the conceptual knowlege instruments shows a value of 0.955 (consistent or reliable).

Experts' construct validation results for the argumentation skill test obtained a mean score of 3.62 (very valid category). The instrument's validity test was done by performing confirmatory factor analysis. It obtained a factor weighting value of > 0.3 and a T-value of ± 1.96 (all argumentation skill instrument items were declared valid). The Alpha Cronbach's coefficient related to the argumentation skill instruments shows a value of 0.815 (consistent or reliable). The normality test criteria is that if a significance value > 0.05 is obtained, then the data is said to be normally distributed. The two instrument data show that the data is normally distributed.

Following the pretest, the classroom utilized RQA, ADI, ADI-Integrated RQA, and traditional learning strategies. The post-test was administered following fourteen sessions of face-to-face instruction in class. Data analysis was conducted using regression analysis at a significance level of 0.05. Prior to the analysis, however, the normality of the data was determined using the One-Sample Kolmogorov-Smirnov test.

FINDING AND DISCUSSION

The results of regression analysis on the correlation between students' conceptual knowledge and argumentation skills in the RQA classroom are summarized in Table 2, Tabel 3, and Table 4.

Table 2. Regression Analysis on the Correlation between Conceptual Knowledge and Argumentation Skills in the RQA Classroom

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,325[a]	,105	,056	6,33966

Table 3. ANOVA test on the Correlation Between Conceptual Knowledge and Argumentation Skills in the RQA Classroom

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	85,183	1	85,183	2,119	,163[b]
	Residual	723,443	18	40,191		
	Total	808,626	19			

Table 4. Regression Coefficient of the Correlation between Conceptual Knowledge and Argumentation Skills in the RQA Classroom

Model		Non-standardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	98,043	13,703		7,155	,000
	Concept-QA	-,282	,193	-,325	-1,456	,163

a. Dependent Variable: ArgRQA

The F value is 2.119 with a significance level of 0.163 > 0.05, as determined by the data analysis results in Tables 2 to 4. Thus, the null hypothesis is accepted, and the research hypothesis is rejected, indicating that no significant correlation exists between conceptual knowledge and argumentation skills in RQA learning. The correlation between conceptual knowledge and argumentation skills in the RQA classroom is illustrated in Figure 1.

Edubiotik: Jurnal Pendidikan, Biologi dan Terapan
Vol. 07, No. 01 (2022), pp. 23 – 35

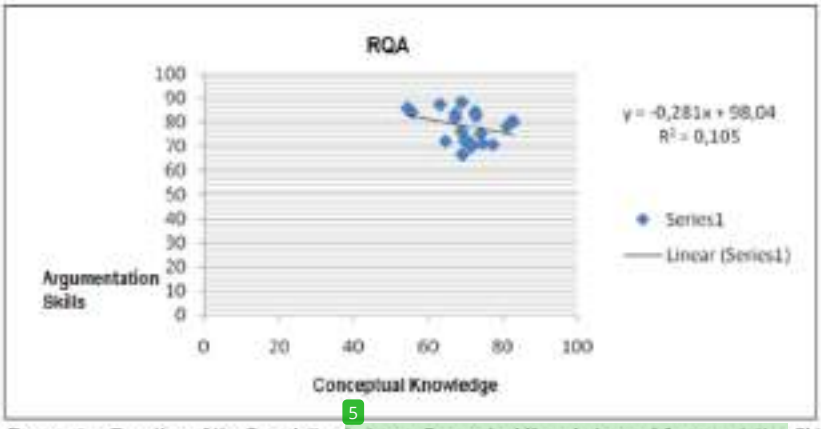

Figure 1. Regression Equation of the Correlation between Conceptual Knowledge and Argumentation Skills in the RQA Classroom

Table 5, Table 6, and Table 7 summarizes the findings of a regression study examining the correlation between conceptual knowledge and argumentation skills in the ADI classroom.

Table 5. Regression Analysis on the Correlation between Conceptual Knowledge and Argumentation Skills in the ADI Classroom

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,423[a]	,179	,153	9,67213

Table 6. ANOVA Test on the Correlation between Conceptual Knowledge and Argumentation Skills in the ADI Classroom

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	633,358	1	633,358	6,770	,014[b]
	Residual	2900,051	31	93,550		
	Total	3533,409	32			

Table 7. Regression Coefficient of the Correlation between Conceptual Knowledge and Argumentation Skills in the ADI Classroom

Model		Non-standardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	39,054	14,021		2,785	,009
	Concept-ADI	,608	,234	,423	2,602	,014

a. Dependent Variable: ArgADI

Based on the results of data analysis in Tables 5 to 7, it is known that the F value is 6.770 with a significance value of 0.014 <0.05. Thus, the null hypothesis is rejected and the research hypothesis is accepted, indicating a significant correlation exists between conceptual knowledge and argumentation skills in the ADI classroom. The regression equation derived from the data analysis is y = 0.608x + 39.05 with a reliability value of 0.179, indicating that conceptual knowledge accounts for 82.10% of argumentation skills and that other factors account for 17.90% of argumentation skills. Figure 2 depicts the relationship between conceptual knowledge and argumentation skills in the ADI classroom.

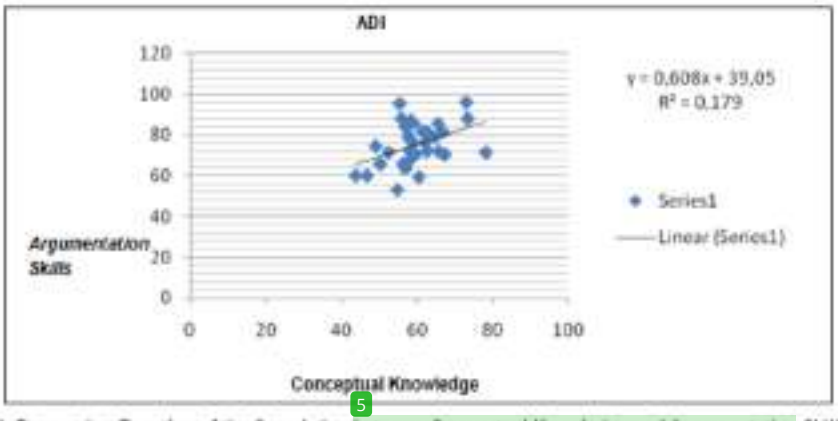

Figure 2. Regression Equation of the Correlation between Conceptual Knowledge and Argumentation Skills in the ADI Classroom

Table 8, Table 9, and Table 10 summarizes the results of a regression analysis of the relationship between students' conceptual knowledge and argumentation skills in the ADI-Integrated RQA classroom.

Table 8. Regression Analysis on the Correlation between Conceptual Knowledge and Argumentation Skills in the ADI-Integrated RQA Classroom

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,283[a]	,080	,055	6,35307

Table 9. ANOVA Test on the Correlation between Conceptual Knowledge and Argumentation Skills in the ADI-Integrated RQA Classroom

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	130,092	1	130,092	3,223	,081[b]
	Residual	1493,375	37	40,361		
	Total	1623,467	38			

Table 10. Regression Coefficient of the Correlation between Conceptual Knowledge and Argumentation Skills in the ADI-Integrated RQA Classroom

Model		Non-standardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	57,096	13,824		4,130	,000
	Concept-ADI-RQA	,302	,168	,283	1,795	,081

The F value is 3.223 with a significance level of 0.081 > 0.05, as determined by the data analysis results in Tables 8 to 10. Thus, the null hypothesis is accepted, and the research hypothesis is rejected, indicating that there is no significant relationship between conceptual knowledge and argumentation skills in the ADI-Integrated RQA classroom. Figure 3 depicts the relationship between conceptual knowledge and argumentation skills in the ADI-Integrated RQA classroom.

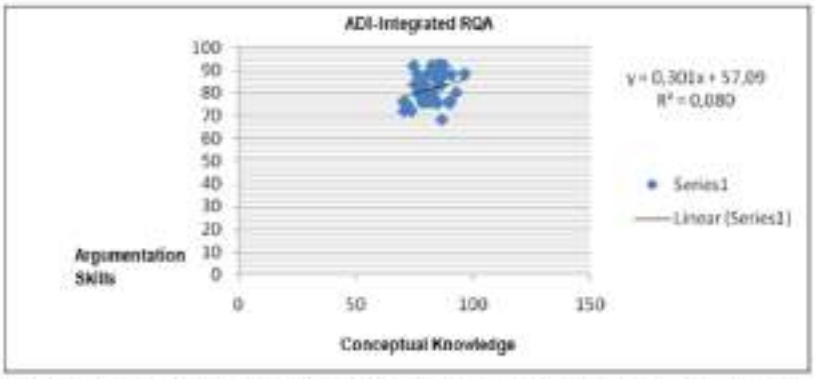

Figure 3. Regression Equation of the Correlation between Students' Conceptual Knowledge and Argumentation Skills in the ADI-Integrated RQA Classroom

Table 11, Table 12, and Table 13 summarizes the findings of a regression study examining the association between conceptual knowledge and argumentation skills in the traditional classroom.

Table 11. Regression Analysis on the Correlation between Conceptual Knowledge and Argumentation Skills in the Traditional Classroom

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,167[a]	,028	-,033	9,87242

Table 12. ANOVA Test on the Correlation between Conceptual Knowledge and Argumentation Skills in the Traditional Classroom

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	44,467	1	44,467	,456	,509[b]
	Residual	1559,434	16	97,465		
	Total	1603,902	17			

Table 13. Regression Coefficient of the Correlation between Conceptual Knowledge and Argumentation Skills in the Traditional Classroom

Model		Non-standardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	51,125	27,385		1,867	,080
	Concept-Gab	,343	,508	,167	,675	,509

The F value is 0.456 with a significance level of 0.509 > 0.05, as determined by the data analysis results in Tables 9 to 11. Thus, the null hypothesis is accepted, and the research hypothesis is rejected, indicating that in the traditional classroom, there is no significant relationship between conceptual knowledge and argumentation skills. Figure 4 presents the relationship between conceptual knowledge and argumentation skills in the traditional classroom.

The significance level of the results of the regression analysis of the association between conceptual knowledge and argumentation skills in the RQA, ADI-Integrated RQA, and traditional classrooms was greater than 0.05. This finding demonstrates that in the classrooms, conceptual knowledge and argumentation skills were not correlated. The extent to which students practice their argumentation skills in the classroom influences their argumentation ability (Apriliani et al., 2019). Students need to make scientific claims that are supported by substantial and pertinent evidence.

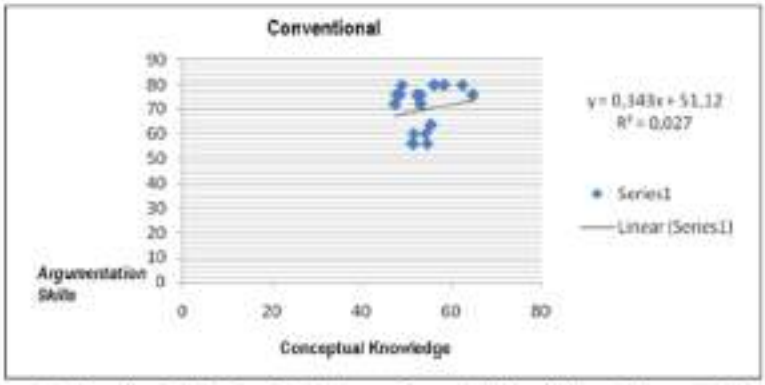

Figure 4. Regression Equation of the Correlation between Conceptual Knowledge and Argumentation Skills in the Traditional Classroom

The lack of familiarity with the RQA and ADI-Integrated RQA learning models contributed to an insignificant relationship between conceptual knowledge and argumentation skills in the three treatment classes. It can be said that the students were unable to adapt to the models' learning stages. Students should spend more time reading and practicing formulating questions in RQA learning. However, many students are unable to prepare adequately for learning due to a lack of appropriate books or references (Amin & Adiansyah, 2018; Amin & Rosmiaty, 2017; Noviyani et al., 2017). Meanwhile, students struggle to follow the stages of scientific investigation in ADI-Integrated RQA learning. Thus far, students have become accustomed to the lecturing method and learning instructions delivered primarily by the lecturer, which has an effect on students' learning autonomy. The lack of variety in the use of supportive learning models results in a lack of self-confidence and self-confidence of students in class (Amin, 2022; Amin & Adiansyah, 2020). Meanwhile, in traditional learning, students are more passive and less motivated to learn because the lecturer directly imparts information. This results in a lack of argumentation skills and conceptual knowledge. Lecturers must facilitate constructivist learning by designing various learning activities that enable students to empower argumentation skills and mastery of concepts that are more adequate (Amin et al., 2021).

Biology Education students at STKIP Pembangunan Indonesia (PI) Makassar, UIN Alauddin Makassar, UPRI Makassar, and STKIP Yapim Maros in South Sulawesi have a low level of higher-order thinking skills (C3 to C6) (Amin & Corebima, 2016). In a written test, these students obtained a low category score (30.90) for argumentation skills, with approximately 41.50% scoring at level 1 and 55.70% scoring at level 2 (Amin, 2017). Furthermore, the mean score on conceptual knowledge achieved by the pre-service biology teachers was 42.35 (low category). The majority of the pre-service biology teachers (77.90%) possessed conceptual knowledge at level of remembering. Over half of pre-service biology teachers (52.01%) were proficient in understanding, 46.91% in applying, 43.83% in analyzing, 35.68% in evaluating, and 30.65% in creating (Amin et al., 2016). Students' adaptability and cognitive level, as well as their thinking ability, become a factor in determining the effectiveness of the learning model or strategy implemented by the lecturer in the classroom.

According to observations and interviews conducted throughout the study, students struggled with compiling and developing the quality of their arguments. These difficulties include those associated with interpreting data, discussing the findings of investigations/inquiries, and relating them to pertinent theories. Numerous factors influence the quality of students' argumentation and conceptual knowledge,

including instrumental factors such as curriculum, programs, facilities, and infrastructure, educator competence, student thinking level, cognitive level, learning motivation, physiological/sensory conditions, learning readiness, and adaptability, as well as classroom-based learning strategies and models.

The quality of arguments is contingent upon students' ability to construct arguments with the appropriate components (Llewellyn, 2013). A low level of conceptual mastery correlates with a low level of argumentative skills, whereas a high level of conceptual knowledge cannot be associated with a high level of argumentative ability (Noviyani et al., 2017). Arguments may not motivate students to acquire scientific knowledge, but they can motivate them to learn and apply scientific knowledge.

According to the findings of this study, there is a correlation between conceptual mastery and argumentation skills in the ADI classroom. Conceptual knowledge contributes 17.90% to argumentation skills, while other factors contribute 82.10%. The ADI learning model has enormous potential for assisting students in developing high-quality arguments (Marhamah et al., 2017). Additionally, by implementing the ADI learning model, conceptual knowledge can be significantly improved (Andriani & Riandi, 2015). There is a relationship between argumentation and critical thinking abilities and the capacity to comprehend Biology concepts (Hasnunidah et al., 2020).

Research by Sadler and Fowler reveals a positive and reciprocal relationship between the argumentation process and conceptual knowledge, especially when the argument relates to real-world situations and contexts (Sadler & Fowler, 2006). Scientific arguments and student achievement have a strong relationship (Safira et al., 2018). One of the elements contributing to pupils' lack of reasoning skills is a lack of conceptual knowledge (Siska et al., 2020). The style of an argument indicates how well one understands a concept and reasoning (Sarira et al., 2019). Students will develop their argumentation skills to their full potential if they can effectively interpret concepts (Llewellyn, 2013). Students can be directed toward learning that develops their courage in communicating and arguing in order to achieve a high level of conceptual knowledge (Mulyani et al., 2021).

The success of implementing a learning model is influenced by one of the students' academic abilities (Safira et al., 2018). The ADI model differs from other methods in providing opportunities for students to design and discover research results and engage in the argumentation process so that they can share and support their ideas (Demircioglu & Ucar, 2015). The students in this study were not sufficiently capable of having adequate academic abilities so that these abilities could contribute significantly to the improvement of argumentation skills. Students do not have enough accommodation in developing arguments in interactive discussions because of the difficulty in adapting to the steps of the ADI model. Students need longer time and greater scaffolding in order to become more independent learners.

Through inquiry-based learning, it is possible to optimize learners' conceptual knowledge (Setiono, 2017). The use of ADI learning significantly improves students' cognitive abilities and conceptual mastery (Fatah et al., 2020). Students who excel at argumentation are believed to also excel at critical reading (Hayati, 2017). Inquiry-based learning activities can have a beneficial effect on students' scientific argumentation skills (Probosari et al., 2016). The ADI learning model is designed to aid in the scientific exploration of the elements that influence learning outcomes (Safira et al., 2018). This instructional model creates an environment conducive to increasing students' knowledge and conceptual knowledge (Prastio & Hasnunidah, 2019). However, since argumentation-based learning, such as ADI, is novel to students, certain phases of learning may take longer than the time limit designed/set prior to learning (Amin & Adiansyah, 2018).

CONCLUSION

In the ADI classroom, there is a correlation between conceptual knowledge and argumentation skills, as revealed by the data analysis and discussion. The regression equation derived from the data analysis is y = 0.608x + 39.05 with a reliability value of 0.179, indicating that conceptual knowledge accounts for 82.10% of argumentation skills and that other factors account for 17.90% of argumentation skills. Besides that, there is no association between conceptual knowledge and argumentation skills in RQA, ADI-Integrated RQA, or traditional classrooms. The null hypothesis is accepted, and the research hypothesis is rejected. This finding can be caused by a variety of reasons, one of which is the pupils' inability to quickly adapt and adjust to the learning model's phases. Improving argumentation quality can be accomplished using active and innovative learning models or strategies.

Based on the research findings, the researcher can continue the research study using the same learning model but with a longer research time. The sampling of research can be more and have the characteristics of higher academic abilities so that the potential of the learning model can be seen more clearly. Factors that contribute positively to conceptual knowledge and argumentation can be further identified through observational assessment during the learning process. Research that reveals the correlation between mastery of concepts and argumentation skills can also be studied at other levels of education or in different courses.

ACKNOWLEDMENT

Acknowledgments to the heads of the biology education department at UIN Alauddin Makassar and Maros Muslim University, biology lecturers at UIN Alauddin Makassar and Maros Muslim University, observers and those who have helped during data collection and analysis of research data.

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