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IMPROVING STUDENTS' SCIENTIFIC ARGUMENTATION ABILITY THROUGH ARGUMENT-DRIVEN INQUIRY LEARNING ACCOMPANIED BY PROCEDURAL E-SCAFFOLDING

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ABSTRACT

Abstract: Scientific argumentation is a communication technique that needs to be improved in the 21st century . Scientific argumentation research that uses argument-driven inquiry learning with procedural e-scaffolding is still limited. In this article, we report the results of research that combines argument-driven inquiry learning with procedural e-scaffolding. This research was conducted in three classes which were divided into ADI-ES class, ADI class, and control class. Learning is done online so that data is collected using the help of google forms. Furthermore, the data were analyzed using ANOVA and post hoc test. The results showed that there were differences in the ability of scientific argumentation before and after learning. Among the three classes, the ADI-ES class has a change in scientific argumentation ability that is better than the other classes . Furthermore, the comment feature on google doc can be further utilized to support *e-scaffolding* during learning.

INTRODUCTION

The contribution of scientific reasoning by students must play a central part in the teaching process (Kuhn, 2010). Scientific argumentation is the practice of gathering and evaluating facts in order to produce explanations of natural occurrences, provide explanations with acceptable arguments, and analyze the validity and justifications from a particular perspective (Sampson & Clark, 2010; Toulmin, 2003). (Ogan-Bekiroglu & Eskin, 2012) and (Hendratmoko et al., 2015). According to the present requirements analysis, teachers have not familiarized students with scientific reasoning abilities in online physics instruction (Khusnayain et al., 2013).

It is not simple to introduce students to scientific argumentation abilities online. This is because training these skills requires effort (Priyadi et al., 2018). One of the responsibilities of teachers is to offer support in phases, often known as scaffolding (Cahyani & Hendriani, 2017). (Hoy & Margetts, 2013; Kamil, 2018; Moran, 2007) Scaffolding is a learning approach that tries to provide aid or direction to students throughout the learning process until they can learn independently. As technology advances, digital-based learning can be integrated with scaffolding. This will generate flexible learning activities, as they will be easily adaptable to students' time and location available (Chandrawati, 2010).

Students' scientific reasoning skills are weakened since discussion activities are brief (Sulistina et al., 2018a). Learning activities that need data collecting from practicum take a considerable amount of time to complete. The application of argument-driven inquiry learning can considerably improve students' knowledge (Bukifan & Yuliati, 2021), particularly the cognitive feature of C2 (understanding) (Andriani, 2016; Rahayu et al., 2019). In addition, the argument-driven inquiry paradigm can cause indicators to propose ideas, examine data, and provide rational support for level 4 scientific arguments (Kacar & Balim, 2021; Kurnasari & Setyarsih, 2017).

During the pandemic, students learn online using their own devices; hence, a learning management system (LMS) is required to facilitate online learning. Google Classroom is a suitable LMS because it allows teachers to efficiently organize, design, and schedule learning assignments, provide input and feedback, and communicate more effectively with their students (Shaharanee et al., 2016). The usage of LMS to provide students with the most e-scaffolding is also noteworthy. The success of online learning platforms will be determined by four key factors: accessibility, collaboration, and speed (Heggart & Yoo, 2018). Google classroom facilitates the development of student learning activities due to its user-friendly characteristics (Al-Maroof & Al-Emran, 2018). Google Doc, Google Form, YouTube, Google Met, and Gmail are among the integrated Google Classroom features that can be utilized as an online learning LMS. These characteristics facilitate e-scaffolding in online learning.

argument-driven inquiry learning model combined with the e-scaffolding approach is a learning paradigm in which students solve actual problems in order to compile their defended arguments. It is anticipated that students will acquire inquiry and higher-order thinking skills (Arends, 2012). In order for the e-scaffolding method to foster students' trust in their own arguments.

Multiple research findings conducted by various scholars indicate that students' reasoning skills are still lacking. The majority of students are only at levels two and three out of five for scientific argumentation (Admoko et al., 2021; Pan et al., 2021; Priyadi et al., 2018). The implementation of argument-driven inquiry learning utilizing the e-scaffolding strategy is anticipated to aid online students in overcoming difficulties with comprehension and developing scientific argumentation skills. Therefore, the following hypotheses are employed in this study:

Ho : In terms of average scientific reasoning, there is no difference between groups of students who received procedural E-scaffolding in ADI learning, ADI learning, and conventional learning.

Hi : Average scientific reasoning differs across groups of students who received procedural E-scaffolding in ADI learning, ADI learning, and traditional learning..

METHOD

The study employed a mixed methods approach with a quasi-experimental design conducted in class XI MIPA SMAN 1 Bangil. The design used is presented in Table 1.

Table 1. Quasi-Experimental Research Design

Class	Pre-test	Treatment	Post-test
Control	X_1	O_1	X_2
Experiment 1	X_1	O2 _	X_2
Experiment 2	X_1	O3 _	X_2

Source: Creswell (2012)

The sample used consisted of three classes selected by cluster sampling. Experimental class 1 learnt by online *Argument-driven inquiry* with Procedural *E-Scaffolding* (ADI-ES), Experimental class 2 learnt by *Argument-driven inquiry* online (ADI), and control class learnt by online learning using google meet with power point application. After the learning was carried out, a post-test was carried out which was then be analyzed to determine the effectiveness of learning in each class.

RESULTS

The statistical descriptions of the pre-test and post-test of students' scientific arguments are presented in Table 2 and the differences in the components of students' scientific arguments in each class are presented in Figure 1.

Table 2. Statistical description of the pre-test and post-test of students' scientific arguments

Class	N	Average	Standard Deviation	Maximum Value
ADIES Experiment Class	36	73.78	12.83	100
ADI Experiment Class	36	52.33	11.29	100
Control Class	36	46.33	11.29	100

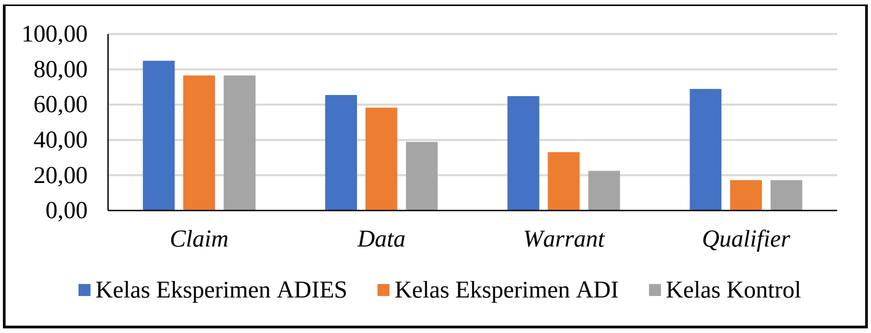

Figure 1. Analysis of changes in the components of scientific argumentation in each class

Hypothesis test results are presented in Table 3.

Table 3. Hypothesis test results using Analysis of Variance

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14988,741	2	7494.370	53,589	.000

Within Groups	14684.222	105	139,850
Total	29672,963	107	

Because the value of Sig. This is smaller than the significance level of =0.05, it can be indicated that there are differences in scientific argumentation between groups of students who were given procedural E-scaffolding in ADI learning, ADI learning, and conventional learning. Furthermore, further tests were carried out with *Post Hoc* with the aim of knowing which teaching method made the average value of scientific argumentation high. The results of the Post Hoc test are presented in Table 4.

Table 4. Further test results (Post Hoc) with Tukey HSD

Test Type	(I) Class	(J) Class	Mean Difference (IJ)	Standard Error	Significance	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	ADI-ES	ADI	21,444	2,787	.000	14.82	28.07
		Control	27,444	2,787	.000	20.82	34.07
	ADI	ADI-ES	-21,444	2,787	.000	-28.07	-14.82
		Control	6,000	2,787	.084	-.63	12.63
	Control	ADI-ES	-27,444	2,787	.000	-34.07	-20.82
		ADI	-6,000	2,787	.084	-12.63	.63

DISCUSSION

Argumentation in education goes beyond asking pupils to express their viewpoint on a presented phenomenon. So that the argumentation process is a sufficient critical thinking technique for pupils to learn to process and analyze different types of information (Haruna & Nahadi, 2021). In addition, students must be able to communicate the outcomes of their study to other groups and attempt to persuade them to agree with them. This is referred to as the justifying procedure. It is necessary for other parties to acknowledge the arguments offered by pupils. This trains kids to be tenacious, trustworthy, and confident in their talents.

The results of the examination of data on scientific argumentation indicate that the three classes differ in their scientific argumentation abilities. In online Argument-driven inquiry learning, the experimental class taught with conceptual e- scaffolding has the greatest average, followed by the experimental class without conceptual e- scaffolding and the control class with the lowest average. All steps of the argument-driven inquiry learning model provide a mechanism for students to become accustomed to scientific argumentation, hence influencing their scientific argumentation skills (M et al., 2019; Rahayu et al., 2019; Sulistina et al., 2018b).

Further tests using Tukey HSD revealed disparities in the scientific reasoning abilities of students who were taught via procedural E-scaffolding in ADI learning, ADI learning, and traditional learning. This is evidenced by the significance value of 0.00, which is less than 0.05, for the procedural e-scaffolding model in ADI learning and ADI learning, but the significance value of 0.08 for conventional learning is larger than 0.05. This is because the ADI-ES learning environment provides access to a variety of learning resources, features, and supportive communication medium, making it easier for the teacher to provide scaffolding. Specifically, scaffolding can improve the quality of learning, including learning outcomes in online learning (Koes-H et al., 2018), and its effects appear to rise with the age of the learner (Doo et al., 2020)

The difference in average test scores and the proportion of markers of scientific reasoning skill between the two experimental courses (ADI-ES and ADI) and the control class was due to the different treatments each class received (Figure 1). With the use of e-scaffolding, the experimental class is able to construct a convincing argument supported by evidence and an explanation of the supporting evidence. The argument claim, data, warrant, and qualifier had a higher average than the ADI class without e-scaffolding and the control group. The ADI class and the control class have about the same average for the claim and qualification components, however the experimental class ADI has a higher average for the data and warrant components. (Kurnasari & Setyarsih, 2017) found that procedural e-scaffolding interventions in argument-driven inquiry learning offered during learning can affect students' scientific argumentation skills. This is due to the fact that all stages of the argument-driven inquiry learning paradigm give students with opportunities to practice scientific argumentation, hence enhancing their scientific argumentation skills (M et al., 2019; Priyadi et al., 2020; Rahayu et al., 2019).

CONCLUSION

Applying the Argument-driven inquiry approach can enhance all indices of scientific argumentation competence. In this study, the ADI-ES experimental class that utilized the argument-driven inquiry learning paradigm in conjunction with e-scaffolding had the best level of scientific argumentation skill. There did not appear to be an average difference between the ADI experimental class and the control class for the claim and qualifier indicators. Only the data and warrant indications contain the average difference. It appears that pupils require e-scaffolding in order to construct convincing arguments. During the COVID-19 pandemic, the necessity for an LMS in learning physics with the ADI model online necessitates e-scaffolding to assist students with argument development.

This research can be used as a reference for teachers and other researchers in the field of physics education or relevant ones in accordance with the implementation of argument-driven inquiry (ADI) learning with procedural e-scaffolding. E-scaffolding on student worksheets still raises some questions for them, then the comment feature on google doc might be used to support e-scaffolding during learning.

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