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Validity of Inquiry-Based Learning Tools on Students' Scientific Argumentation Ability

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ABSTRACT

Objective: This study aims to describe the validity of inquiry-based learning tools on students' scientific argumentation abilities. The validity of the developed device is viewed from the aspects of content, language, and presentation. This type of research is pre-experimental without a control group. **Method:** The method used is the 4D model (define, design, and development), which is modified and implemented in the Postgraduate Program in Science Education, State University of Surabaya. The data collection technique was carried out using the learning device validation method. The assessment instrument uses a device validation sheet. The tools developed include LIP, ST, SAS, and students' scientific argumentation ability tests. Three biology lecturers assessed the validity of this inquiry-based learning tool. Data analysis was conducted quantitatively, and the Aiken validity index and reliability were calculated. **Results:** The validation results obtained the validity index Aikens LIP 0.97, ST 0.93, SW 0.99, and scientific argumentation test 1.00 with high validity and reliability categories. **Novelty:** the researcher considers that not many previous studies have conducted research on the material of the Human Respiratory System, especially in class XI Science based on guided inquiry which includes five indicators of scientific argument, namely claims, ground used, warrants given, counterarguments generated and rebuttal offered. However, this research focuses on the validation analysis of inquiry-based learning tools on high school students' scientific argumentation abilities.

INTRODUCTION

This 21st century learning era requires a student to have independence in learning and develop the ability to adapt to the era. The curriculum demands in the 21st century are that the learning process must be student-centered. According to Septikasari (2018), the challenge in learning science in the 21st century is the development of 4C. The 4C term includes communication, collaboration, critical thinking and problem-solving, creativity, and innovation (Septikasari, 2018). In line with Putri (2021), the skills expected in the 21st century are critical thinking, problem-solving, collaboration, contextual learning, media and information technology literacy, and argumentation skills. Based on this statement shows that scientific argumentation skills are essential to training students. Students can communicate, think critically, and establish collaborations through scientific argumentation skills while demonstrating creativity. Students will be able to analyze scientific problems according to facts and evidence.

According to Grooms (2020), scientific argumentation is stating scientific findings based on evidence. Scientific argumentation is an important activity. They submitted ideas based on harmony between claims, data, evidence, and theory. This is supported by Wikara (2022), who argues that argumentation skills are necessary to solve many life

challenges in real life. For example, educational, social, economic, or political activities require argumentation skills. Therefore, more than implementing learning in the field should be required to equip students with the knowledge to be trained, such as the ability to solve problems. Problems, skills in arguing scientifically, and critical thinking skills to apply them in social life (Gabriel et al., 2020). The scientific argumentation ability refers to Toulmin's Argument Pattern (TAP). Toulmin (2003) argues that an argument is obtained from a series of interconnected sentences and is based on a statement that is believed to be accurate, namely claim (C), ground/data (D), warrant (W), and backings (B). Arguments can be challenged in rebuttals (R) or counterarguments, presenting facts contrary to the data, warrants, or backings to prove the statement is true.

Based on field observations conducted at the research school, the ability of scientific argumentation still needs to improve. This is evidenced when students are asked about learning with scientific arguments that most students do not understand. Students state that most of the learning received at school only emphasizes knowledge and understanding of concepts that need to be trained skills, especially related to scientific argumentation abilities. In addition, reinforced by the results of the analysis of lesson plans used by teachers at the research site, argumentation skills have not been taught. This is evident in the absence of argumentation ability as a learning goal, not in the learning steps. Some items in the assessment instrument measure student learning outcomes, so this impacts the low ability of students' scientific argumentation. Dawson & Carson (2020) state that only some teachers still apply scientific argumentation skills in schools. This aligns with Pangestika et al. (2017) that most students need more scientific argumentation skills. The arguments made by students need to be stronger in terms of evidence and support, so they cannot guarantee the truth of the claims submitted.

The scientific argumentation ability that is applied requires linkage with the learning model so that its implementation can be maximized. The selection of a suitable learning model also affects the quality of learning, which has implications for students' argumentative abilities. One model that is an alternative for practicing argumentation skills is the Guided Inquiry learning model. According to Nurmayani & Doyan (2018), the guided inquiry learning model is an investigation-based learning model in which students seek answers to their problems through investigative activities. Nurdyansyah & Fahyuni (2016) also emphasized that through guided inquiry, learning will begin with formulating problems, developing hypotheses, testing hypotheses, drawing temporary conclusions, and testing these temporary conclusions to arrive at conclusions that are believed to be accurate. Scientific argumentation is closely related to inquiry-based learning, which involves a lot of investigative and experimental activities that involve a lot of experimental data. Experimental activities can support students in creating scientific argumentation skills because they act as a medium for providing evidence in the form of supporting data for scientific arguments.

Scientific argumentation, especially in learning biology, can help students build complete and meaningful biological knowledge. Respiratory System material is related to concrete scientific facts about natural phenomena and abstract objects. Material characteristics in the respiratory system contain content in the form of tissue structures that make up the respiratory system related to the mechanism of human breathing, and the total lung capacity cannot be observed directly. Students can only observe the symptoms and consequences of the processes that arise during the investigation. This

puts the investigation in dire need of guidance from the teacher so that the concepts constructed by students can be formed as a whole. Students also need to be directed to carry out investigations so that the achievement of the indicators listed in the lesson plans can be fulfilled optimally.

Research by Erdani et al. (2020) showed that students could discover material concepts independently through guided inquiry learning through experimental activities. Sandhy et al. (2018) stated that there was an increase in students' argumentation skills on vibration and wave material which was taught using the inquiry learning model at 3rd State JHS Pontianak. In line with Hidayah et al. (2022), Applying the guided inquiry model using a virtual laboratory affects students' scientific argumentation skills in learning natural sciences in junior high schools. Based on this description, the researcher considers that not many previous studies have conducted research on the material of the Human Respiratory System, especially in class XI Science based on guided inquiry which includes five indicators of scientific argument, namely claims, ground used, warrants given, counterarguments generated and rebuttal offered. However, this research focuses on the validation analysis of inquiry-based learning tools on high school students' scientific argumentation abilities.

RESEARCH METHOD

This research is a pre-experimental study with three repetitions without a control group. Before experts validate the device, the device developed is first designed using the 4D model (define, design, and development), which was adapted from Thiagarajan et al. (1974) in Ibrahim (2002). This research was tested on 16 students in class XI Science. The learning tools developed include Learning Implementation Plans (LIP), Student Textbooks (ST), Student Activity Sheets (SAS), and Student Scientific Argumentation Tests. The device was then reviewed and validated by three expert lecturers. The assessment instrument used in this study was the learning device validation sheet. The feasibility of a learning device is measured based on expert judgment on the validation sheet. The range of values used in the assessment of this validation sheet starts from 1 to 4, with a category score of 4 being very good. A learning device will be declared to have high validity if it has an Aikens validity index of 0.68-1.00 (Aiken, 1980). The learning device validation procedure starts with problem analysis, gathering information, designing learning device designs, and content validation by expert lecturers.

Data validation results of learning tools were analyzed using a rating scale. The Aikens item validity index then calculates the validation results from the validator on all indicators assessed with the following formula (Aiken, 1980).

$$V = \frac{\sum s}{[n(c-1)]} \dots\dots\dots\dots (1)$$

$$S = r - l_0 \dots\dots\dots\dots\dots\dots (2)$$

Information:

V : Item Validity Index
S : Difference between (r) and (l_0)
r : The score given by the assessor
l_0 : the lowest validity value
c : the highest validity number
n : number of members

Table 1. Criteria for learning devices based on the value of the validator.

	Score	Category
1	0.68-1.00	High
2	0.34-0.67	Moderate
3	0.00-0.33	Low

(Aiken, 1980)

Learning devices that have been assessed for validity will then be calculated for the percentage of reliability. The reliability percentage is calculated using the following formula (Borich, 1996).

$$R=\left(1-\frac{A-B}{A+B}\right)\ x\ 100\%$$

Information:

R : Reliability of the instrument (Percentage of Agreement)

A : A higher score than the validator

B : Lower score than the validator

Learning device reliability is considered valid if the reliability value is ≥0.75 or ≥75% (Borich, 1996).

RESULTS AND DISCUSSION

Results

LIP

LIP is a design that describes the learning process and implementation of learning in order to achieve the essential skills that are applied in content standards and contained in the syllabus. The developed LIP includes two meetings. The results of the validation of inquiry-based lesson plans for high school students scientific arguments are presented in Table 2.

Table 2. LIP validation results.

No.	Aspects	Rating Score			Aikens V	Categories
		Validators 1	Validators 2	Validators 3		
1	LIP identity	4.00	4.00	4.00	1.00	High
2	Time Allocation	4.00	4.00	3.66	0.96	High
3	Learning Indicators	3.00	4.00	3.33	0.81	High
4	Learning objectives	4.00	4.00	4.00	1.00	High
5	Learning materials	4.00	4.00	4.00	1.00	High
6	Methods, media, and learning resources	4.00	4.00	4.00	1.00	High
7	Learning Steps	4.00	4.00	4.00	1.00	High
8	Scientific Argumentation Indicator	4.00	4.00	4.00	1.00	High
9	Evaluation	4.00	4.00	4.00	1.00	High
Validation Average Score					**0.97**	**High**
Percentage of Agreement					**97.88**	**Reliable**

Based on the validation results, the lesson plans developed are assessed from several aspects and get an average Aikens validity index of 0.97 in the high category. The reliability value is 97.88% in the reliable category. The suggestions given by the validator related to the developed lesson plan are adding pretest and posttest activities

to learning activities, in the closing activity, inviting students to study the material at the next meeting, and giving awards to active students in learning activities.

ST

ST is a student handbook to make it easier to find information related to the material on the Human Respiratory System and contains exercises that can train students' scientific argumentation abilities. The developed textbook contains the steps of the inquiry learning model. The description of the developed ST is presented in Figure 1 and Figure 2.

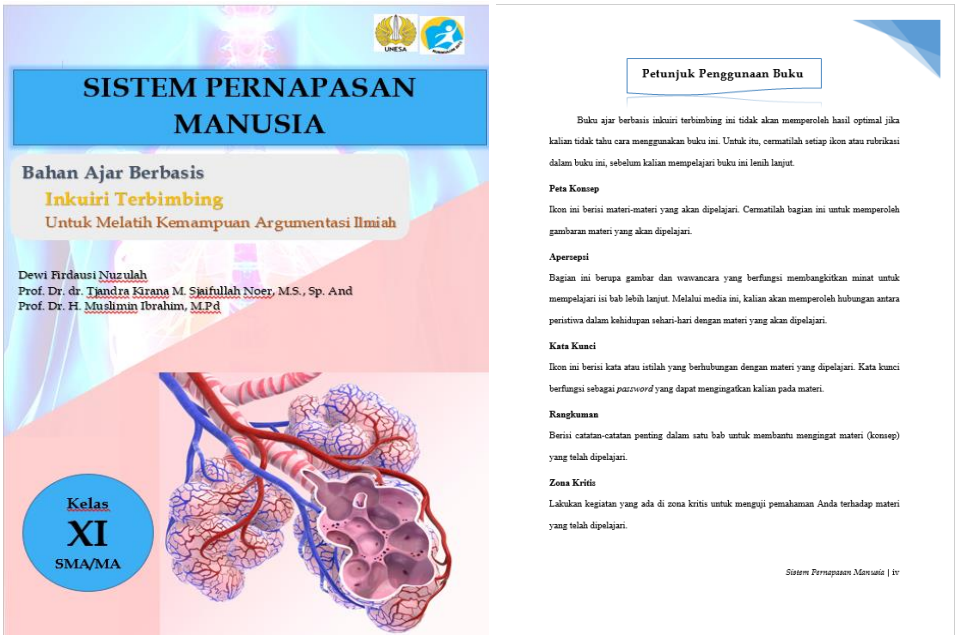

Figure 1. Display of inquiry-based student textbooks.

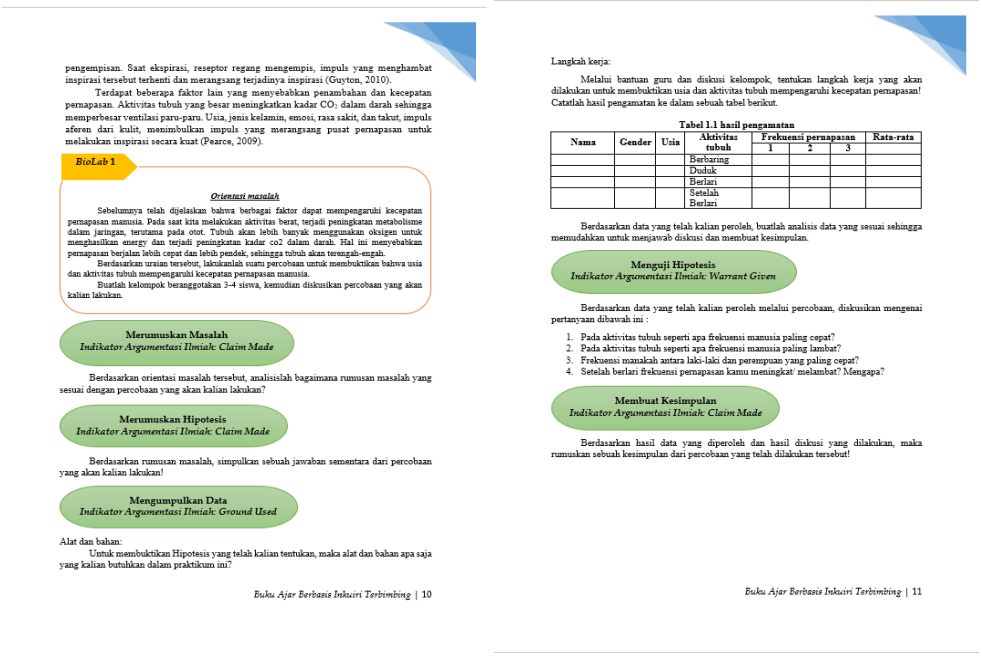

Figure 2. Inquiry model steps and indicators of students' scientific arguments in student textbooks.

The results of the developed ST validation are presented in **Table 3**.

Table 3. ST validation results.

No.	Aspects	Rating Score			Aikens V	Categories
		Validators 1	Validators 2	Validators 3		
1	Content Eligibility	3.58	4.00	3.66	0.91	High
2	language	3.77	4.00	3.77	0.95	High
3	Presentation	3.75	4.00	3.75	0.94	High
Validation Average Score					**0.93**	**High**
Percentage of Agreement					**95.76**	**Reliable**

Based on the validation results, it can be seen that the ST developed has an Aikens validity index value of 0.91, linguistic adequacy of 0.95, and presentation feasibility of 0.94. The average validation result is 0.93 in the high category and is feasible to apply, and the reliability value is 95.76% in the Reliable category. The validator's advice regarding the developed ST is to use a comfortable font, and the textbook header is straightforward.

SAS

SAS is a guide for student activities during the learning process. The SAS developed in this study is an inquiry-based SAS to train scientific argumentation skills on the subject of the Human Respiratory System. This SAS applies the steps of the inquiry model designed to train students' scientific argumentation abilities. There are two SASs developed, namely SAS 1 and SAS 2. The description of the developed SAS is presented in Figure 3 and Figure 4.

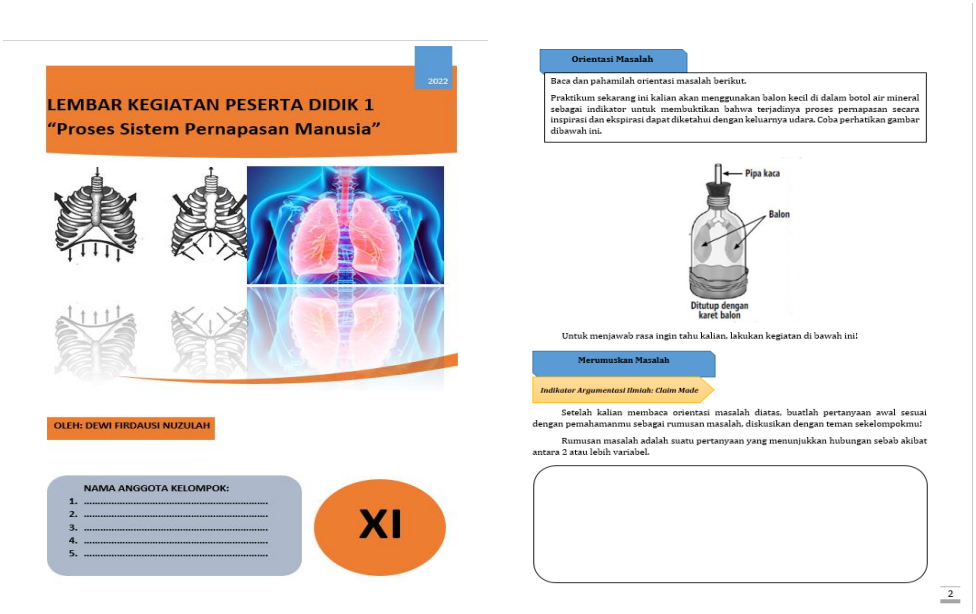

Figure 3. Display inquiry steps and scientific argumentation indicators on SAS-1.

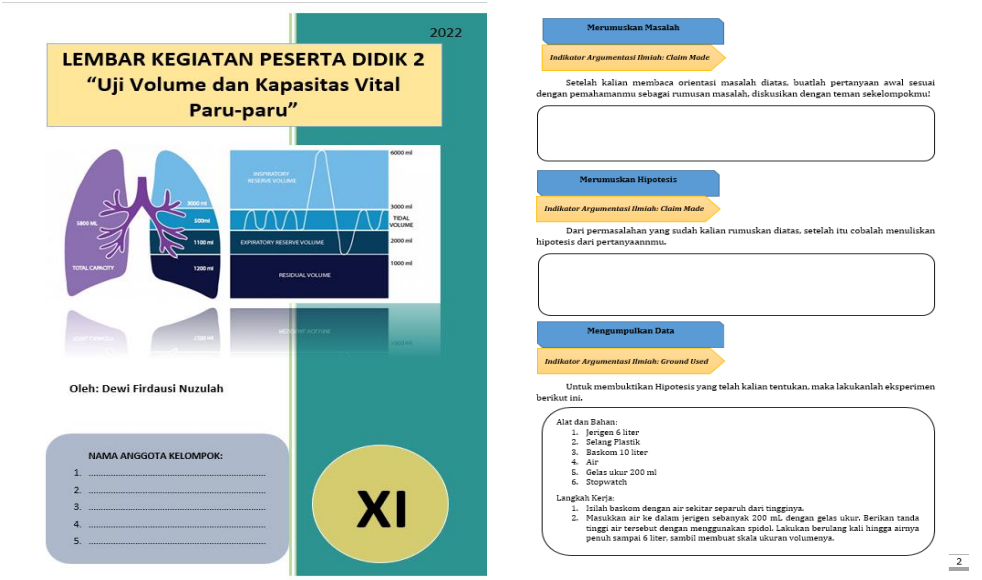

Figure 4. Display inquiry steps and scientific argumentation indicators on SAS-2.

The results of the developed SAS validation are presented in **Table 4.**

Table 4. SAS validation results.

No.	Aspects	Rating Score			Aikens V	Categories
		Validators 1	Validators 2	Validators 3		
1	Content Eligibility	4.00	4.00	4.00	1.00	High
2	language	4.00	4.00	4.00	1.00	High
3	Presentation	4.00	4.00	3.91	0.99	High
Validation Average Score					**0.99**	**High**
Percentage of Agreement					**99.35**	**Reliable**

Based on the validation results, the developed SAS has an Aikens validity index of 1.00 for content feasibility, 1.00 for language appropriateness, and 0.99 for presentation feasibility. The average validation result is 0.99 in the high category and is feasible to apply, and the reliability value is 99.35% in the Reliable category. The suggestions the validator gave related to the developed SAS are adding abbreviated term descriptions to the SAS table.

Student Scientific Argumentation Test

Scientific argumentation ability test sheets contain questions in descriptions helpful in checking students' scientific argumentation abilities before and after the learning process using guided inquiry learning tools. The results of the validation of scientific argumentation test instruments are presented in Table 5.

Table 5. Validation results of scientific argumentation tests.

No.	Item indicator	Validation Average Score			Aikens V	Category
		V1	V2	V3		
1.	Make a series of sentences that are believed to be true (Claim) about the conclusions of the	4	4	4	1	High

No.	Item indicator	Validation Average Score			Aikens V	Category
		V1	V2	V3		
	experiment based on the reading provided					
2.	Analyzing the data (Ground Used) about the data that becomes a reference based on the reading provided	4	4	4	1	High
3.	Prove the truth (Warrant) regarding the treatment which results in high respiratory frequency based on the readings provided	4	4	4	1	High
4.	Make alternative rebuttals/ideas (counterargument generated) about the treatment which results in low respiratory frequency based on the readings provided	4	4	4	1	High
5.	Strengthen the rebuttal (Rebbutal Offered) to the problem by making conclusions from the experiments that have been provided	4	4	4	1	High
	Final Average Score				**1**	**High**
	Percentage of Agreement				**100% (R)**	

Based on the validation results, the scientific argumentation test instrument developed has an Aikens validity index value from the three validators of 1 in the high category. The reliability value is 100% in the Reliable category. This shows that the developed scientific argumentation test instrument is feasible to apply.

Discussion

Learning tools, namely everything or several preparations prepared by the teacher individually and in groups so that the implementation and evaluation of learning can be carried out systematically (Wildan, 2017). LIP is an essential component that teachers must own to support the learning process, according to Arifin (2017). The validity of the developed lesson plans obtained very good results. The same results were found in research by Safirah et al. (2022), Mulya et al. (2022), and Masithah et al. (2022) stated that the results of the validity of the lesson plan implementation also obtained very good results. According to Fahrurrozi & Mohzana (2018), the teacher's ability to prepare lesson plans is very important to the success of the learning process. The LIP developed is valid if it contains appropriate learning steps, includes the methods and media used in learning, involves students, and there is a time allocation for each step of the learning process.

According to Hendratmoko et al. (2016), implementing a guided inquiry learning model with practicum activities can increase scientific argumentation skills. The steps of the guided inquiry model were developed through formulating problems, designing and experimenting, collecting data, analyzing data, and making conclusions accompanied by teacher guidance (Dianty et al., 2020). The validity of the developed ST obtained very good results. The same results were obtained by Yulinda et al. (2022), Matsun et al. (2020), and Haspen et al. (2021), stating that the validity of textbooks based on content feasibility, language, and presentation obtained good results. According to Fadli et al. (2017), the more appropriate the selection of letters with the clarity of the images in the developed media, the greater the chance for students to

absorb teaching material after reading it. This statement proves that the readability of a media is influenced by the suitability of the use of letters in the contents of the media to make it easier for readers to understand.

The validity of the developed SAS obtained very good results. Tampubolon et al. (2021), Safirah et al. (2022), and Zakaria et al. (2020) stated that the validity of SAS based on content and construct validity obtained very good results. According to Hulu & Dwiningsih (2021) that the language used in the developed SAS greatly influences the clarity of a piece of writing. According to Nieveen (in Plomp & Nieveen, 2013), validity can be seen from two things, namely content validity (relevancy) and construct validity (consistency). The content validity in question is that intervention is needed, and the design is based on existing scientific knowledge. Meanwhile, construct validity is viewed from the design of interventions per the proper logic/reasons.

The validity of the argumentation ability test that was developed obtained very good results. Berlian et al. (2021), Zaroh et al. (2022), and Devy et al. (2020) found that the validity of the scientific argumentation ability test instrument obtained good results. According to Fitri (2017), the higher the value of the validity and reliability of an instrument, the more accurate the data obtained. This proves that the research instruments' quality remarkably determines the research results. In line with Arifin's research (2017) that instruments have a significant role in research. This is because, with instruments, the quality of research can be known. So if the developed instrument has good criteria, the quality of the research will also be good and vice versa. One way for the learning process to run effectively is to evaluate the results of learning tests obtained after the learning process. This evaluation shows which components of the learning process are still weak, so improvements need to be made (Khaeruddin, 2015).

CONCLUSION

Fundamental Finding: Inquiry-based learning tools for students' scientific argumentation skills in High School Human Respiratory System material that have been developed are suitable for learning. **Implication:** The tools developed are LIP, ST, SAS, and scientific argumentation tests with high and reliable Aiken validity index values. **Limitation:** The research was carried out until the development stage, but the dissemination stage still needs to be done. **Future Research:** There is a need for further development, primarily guided inquiry-based learning tools to practice scientific argumentation skills in other materials and broader dissemination.

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