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Development of Student Worksheets Based on Argument-Driven Inquiry Learning Model to Improve Students' Critical Thinking Skills

Rida Aisyah Putri, *Setyo Admoko
Physics Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya, Ketintang Campus, Surabaya 60231, Indonesia
*Corresponding Author e-mail: setyoadmoko@unesa.ac.id

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Abstract

This study aims to describe the validity, effectiveness and practicality of a student worksheet development using the Argument-Driven Inquiry (ADI) learning model to practice students' critical thinking skills on Hooke's Law material. The type of research in this case is Research and Development with the ADDIE development model. The subjects in this study were 20 students of class XI Mathematics and Natural Sciences 4 at SMAN 18 Surabaya. The data obtained from this study are the results of the validation of the student worksheets, the pre-test and post-test results, and the questionnaire responses to the student worksheets. The research instrument was validated by 2 lecturer The results of the student worksheets based on ADI learning model validation were analyzed using quantitative descriptive analysis This study found that the results of the validation of the average student worksheets of the ADI learning model on Hooke's Law material to practice students' critical thinking skills are 88.6% with valid categories, the average student pre-test and post-test results are 46 and 80.8. The standard gain value is 0.64, which shows the effectiveness of using student worksheets for the argument-driven inquiry learning model in the medium category. The results of the student response questionnaire were 89.16%, with a very practice category. These results show that the development of student worksheets based on ADI learning model obtained valid, effective and practice categories to improve students' critical thinking skills on Hooke's Law material.

Keywords: student worksheets, argument driven inquiry, critical thinking skills

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INTRODUCTION

The learning process according to the 2013 Curriculum is learning that includes the development of skills needed in the 21st-century. Learning paradigm in the 21st-century accents the ability of students to obtain information from many sources, think analytically, formulate a problems, collaborate, and cooperate in problems solving. 21st-century skills considered capable of intellectual capital and strengthening social can be abbreviated as 4C. 4C skills consist of characteristics of communication, critical thinking, collaboration, and creativity (Ferry Doringin, 2017). One of the aspect of 21st-century skills is learning that practice critical thinking skills.

Critical thinking skills are one of the aspect that are needed in learning activities in the 21st-century. Students will need critical thinking skills in their personal and professional lives (Bezanilla et al., 2019). To make effective decisions, students must be able to solve problems. That is why they must have critical thinking skills (Yulita et al., 2018). Critical thinking is thought with reasonable consideration to decide what to believe or do (Ennis, 2018). The benefit is that it can help students analyze learning in detail and arouse curiosity about the available information to achieve a deep understanding and develop their expertise in their

field (Suraya et al., 2019). Critical thinking skills are essential in the world of education to solve problems that arise from the knowledge gained by students. Therefore, efforts to practice critical thinking skills in the educational process are important.

Students in Indonesia their critical thinking skills that are still below international standards. This statement is supported by the PISA scores of Indonesian students in 2015 and 2018. In 2015 the results of PISA science students from Indonesia ranked 64th among 72 countries with a score of 403 points. In 2018 the results of PISA science students from Indonesia were 396 points.. The data is taken from the OECD for the PISA test held in 2015 and 2018. Based on these scores, it can be known that the PISA scores of Indonesian students have decreased (OECD, 2018). In addition, Indonesia is one of the countries included in the lower PISA countries. This is because students in Indonesia have knowledge but cannot apply it in everyday life (Kurniasari et al., 2017). The questions used in PISA are problem-solving questions that known students' abilities in higher-order thinking; in solving these problems, students are required to think critically. The results of the PISA study prove that student in Indonesia, their critical thinking skills are still relatively low.

One of the efforts to practice critical thinking skills is to involve students in argumentation. Argumentation is a prosperous domain in contributing to improving science education. Argumentation is very important in science and should be taught in science learning (Erduran & Jiménez-Aleixandre, 2008). Student involvement in argumentation can encourage critical thinking in science learning (Bathgate et al., 2015). Critical thinking skills have a relationship with argumentation skills. In the critical thinking indicator, there is a simple explanation. One of its sub-aspects is analyzing arguments. The indicator identifies what reasons are stated or not and looks for the components of an argument. So, it can be said that if someone has good critical thinking skills, they will have good argumentation skills (Nufus et al., 2018). Argumentation is the object of activity and can be defined as the skills students should possess to support claims, to make connections between the facts they learn, and to transfer knowledge achievements into everyday life examples (Erduran, 2018).

Based on the above problems, an appropriate learning model is needed because learning activities are important. The integration of arguments in science learning will be more effective if supported by appropriate learning models (Putri et al., 2020). One model or learning strategy that has the potential to develop students' critical thinking skills is the Argument-Driven Inquiry (ADI) learning model (Sampson et al., 2011). ADI learning model is designed to prepare and give opportunities for students to develop their methods of obtaining data, conducting investigations, using data to answer investigative questions, writing, and thinking more reflectively (Sampson & Walker, 2012). This learning model can help students develop thinking habits and critical thinking by emphasizing the important role of argumentation in generating and validating scientific knowledge (Sampson & Clark, 2011).

In the learning process, apart from a education that can practice students' critical thinking skills, there is a learning device that is interconnected with each other. One of the tools used in the 2013 curriculum learning is student worksheets. Learning media such as student worksheets can help students understand certain concepts, and learning is not teacher-centered but student-centered (Septiaahmad et al., 2020). Student worksheets can support teaching and learning activities between teachers and students (Umbaryati, 2018). Student worksheets as media and learning materials that are effective and can produce meaningful knowledge. Then student worksheets should contain questions and guidelines for conducting investigations or problem solving those direct students to gain direct learning experiences oriented to the learning model (Canna Orenta Elcane et al., 2021).

Based on observations at SMAN 18 Surabaya, physics learning has not used student worksheets as a learning media. Learning in class only uses books and modules that contain material and practice questions. The teacher becomes the center of learning and students only become object of receiving the theory from the teacher and doing practice questions, This can make students passive. Meanwhile, based on currently developing theories, it is highly

recommended to conduct learning that can engage and activate students (Suarti et al., 2020). Previous research has found by developing student worksheets. The research that has been carried out by Purnama Sari et al., (2020) regarding the development of student worksheets with a scientific approach to improve critical thinking skills of high school students and produce valid products with a total percentage of validity test is 88.5% in the very good category. Research on the development of student worksheets has been carried out by Calesta et al., (2021) based on guided inquiry assisted by E-Learning to improve understanding of concepts in class X SMA students and produce valid and practical products in improving students' conceptual understanding. Research on the development of student worksheets has been carried out by Firdaus & Wilujeng, (2018) based on guided inquiry to improve critical thinking skills and student learning outcomes to produce products that can improve students' critical thinking skills with a standard gain of 0.43 and an increase in student learning outcomes with standard gain of 0.34. There are several differences between previous research and this research, namely in the learning model and material. The learning model used in this research is Argument Driven Inquiry with Hooke's Law material. Learning physics is closely related to direct experience of the concept of physics theory so students have the opportunity to develop knowledge. Therefore, research is needed that develops learning media in student worksheets containing Hooke's material that can make students learn independently and develop students' critical thinking skills through the Argument-Driven Inquiry (ADI) learning model. According to Ennis, (2011) critical thinking indicators have six basic elements, namely focus, reason, interference, situation, clarity, and overview. These indicators are trained in student worksheets which will be developed in student worksheets. Based on this description, this article aims to describe the validity, effectiveness, and practicality of a student worksheets development using the Argument-Driven Inquiry learning model to improve students' critical thinking skills on Hooke's Law material.

METHOD

The research used is a type of Research and Development (R&D) (Sugiyono, 2016). This research use ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. Subjects in this research were 20 students of XI Mathematics and Natural Science 4 class in the even semester of the 2021-2022 academic year at SMAN 18 Surabaya. The flow chart for the stages of development research can be seen in Figure 1.

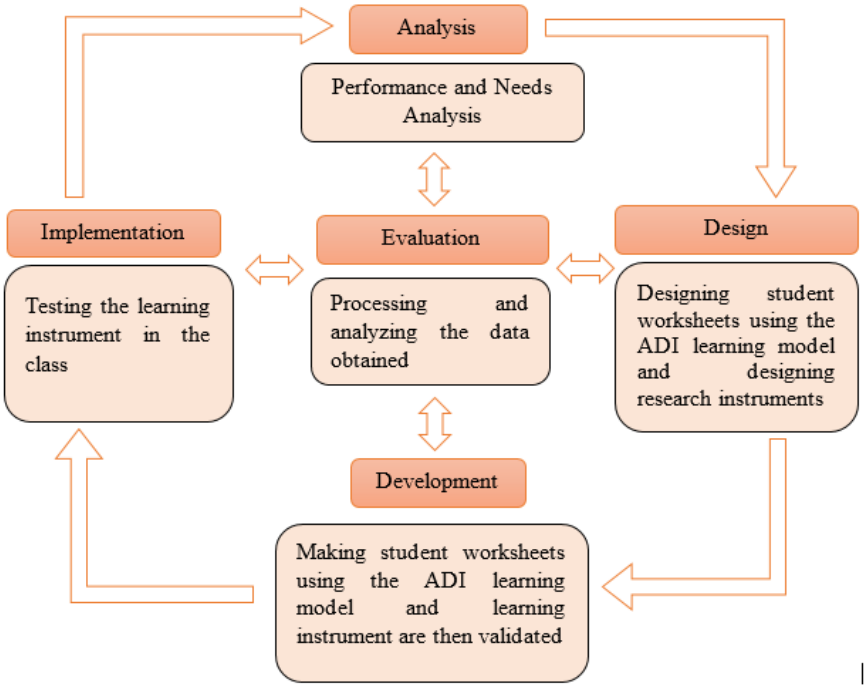

Figure 1. Research design of student worksheets development

Figure 1 shows that the ADDIE flowchart has 5 phases. Analysis phase, the initial step in developing of student worksheet with an Argument-Driven Inquiry (ADI) learning model on Hooke's Law material is to conduct performance analysis and needs analysis to collect various information to determine what students need to understand physics concepts easily. Researchers analyze the causes of student worksheets need to be developed.

In the design phase, the researchers was to start designing student worksheets that would develop according to the previous analysis results. Then, the researchers designed research instruments and learning instruments such as student worksheets. Following the syllabus, lesson plans, handouts, and test questions have referred to ADI learning model to practice students' critical thinking skills on Hooke's Law material.

In the development phase, after finishing designing student worksheets. In this phase, the student worksheets draft is started, and the learning instrument are perfected, such as the syllabus, lesson plans, pretest and post-test questions, and student response questionnaires to be applied in classroom learning. After all the products are finished, they are validated by experts. Physics lecturers carry out the validation process, and each validator will assess the product with an assessment instrument. The assessment from the validator can be used as the basis for improvement so that student worksheets and other instrument can be applied in classroom learning.

In the implementation phase, the development results of the students' worksheets designed and other learning instrument were assessed by the validator. Then the product trials were developed in learning in XI Mathematics and Natural Science 4 class at SMAN 18 Surabaya. The aim is to determine the feasibility of student worksheets in effectiveness and practicality through pretest and post-test questions and filling in student response questionnaires. The learning process is carried out online through google meet.

In the evaluation phase, the researcher was processes and analyzes the data obtained from the implementation phase, data from the pretest and post-test results, and student response questionnaires. The aim is to determine of student worksheets in validity, practicality and effectiveness.

The instruments used in this study were: (1) pretest, researcher gave the pretest to the students to determine the student's initial abilities before applying student worksheets based on Argument-Driven Inquiry (ADI) learning model on Hooke's Law material; (2) post-test, researchers gave the post-test to students to determine the final ability of students after learning with the student worksheets based on ADI learning model on Hooke's Law material, (3) student response questionnaires, researchers gave student response questionnaires to determine the practicality of the student worksheets based on ADI learning model on Hooke's Law material. The data obtained from this study are: (1) the results of the student worksheets validation; (2) pretest results; (3) post-test results; (4) student response data on the use of the student worksheets based on ADI learning model.

The validity of research instrument and learning instrument based on the ADI learning model was analyzed after the learning media products were validated first. The validation results are then calculated using the following equation :

$$score\ validity = \frac{\sum x}{x_{maks}} x100\%$$

The results of the score calculation are converted into level of validity criteria according to (Purwanto in Lestari et al., 2018) as follows:

Table 1. Level of validity

Score interval	Criteria
$0 - 54\%$	Invalid
$55\% - 64\%$	Less Valid
$65\% - 79\%$	Enough
$80\% - 89\%$	Valid
$90\% - 100\%$	Very Valid

The pretest and posttest scores were analyzed using standard gain, which aims to known the improvement of critical thinking skills before and after treatment. Moreover, to test the product's effectiveness developed through the students' pretest and posttest questions. To find standard gain with the following equation:

$$N - gain = \frac{\bar{x}_{posttest} - \bar{x}_{pretest}}{skor\ maks - \bar{x}_{pretest}}$$

The standard gain calculation results are converted into criteria (Hake in Apriyana et al., 2019) as show in Table 2.

Table 2. N-gain Criteria

Standard Gain Value	Criteria
$N - gain > 0{,}7$	High
$0{,}7 \geq N - gain \geq 0{,}3$	Medium
$N - gain < 0{,}3$	Low

Data from student response questionnaire were analyzed to determine the practicality of student worksheets based on the ADI learning model, so it can be analyzed using the following equation:

$$P = \frac{\sum x}{xmaks} x100\%$$

The results of the percentage calculation are converted into criteria (Riduwan, 2015)

Table 3. Questionnaire Response Criteria

Score interval	Criteria
$0 - 20\%$	Very Less Practice
$21\% - 40\%$	Less Practice
$41\% - 60\%$	Enough
$61\% - 80\%$	Practice
$81\% - 100\%$	Very Practice

RESULTS AND DISCUSSION

The results of this study are development of student worksheet based on ADI learning model on Hooke's Law to practice students' critical thinking skills. In this study using the ADDIE development model, which has five phases. The following are the results of the research stages of developing student worksheets.

Analysis phase: At this stage, there are two analyzes, namely performance analysis and needs analysis. Based on these observations, the researchers found that learning physics has not used student worksheets as learning media. Learning in class only uses books and modules that contain material and practice questions. While learning process in the physics class, the teacher becomes the center of learning and students only become the object of receiving the material and doing practice questions. While learning physics is related to direct experience of the concept of physics material so that students have the opportunity to develop knowledge. Therefore, the researchers developed student worksheets based on the ADI learning model on Hooke's Law material to improve students' critical thinking skills.

Design phase, at this stage, the researcher designs student worksheets based on the ADI learning model, designs research instruments and learning instruments that will be used. The results of the student worksheet designs are: (1) the format used in the student worksheets; (2) work procedures following the use of student worksheets; (3) core competencies and

basic competencies in student worksheets; (4) Hooke's Law materials; (5) questions used to practice critical thinking skills; (6) experiments according to Hooke's Law; (7) bibliography.

In the development phase, at this stage, the researcher made student worksheets using the ADI learning model with Hooke's Law material and research instruments such as learning instruments (syllabus, lesson plans, handouts, pretest, and posttest questions) and student response questionnaires, and made validation sheets. The development of student worksheets refers to the syntax of the ADI learning model uses indicators of critical thinking skills. Products developed using Microsoft Word follow the format designed in the design phase. The following are some of the results of developing student worksheets based on ADI learning model

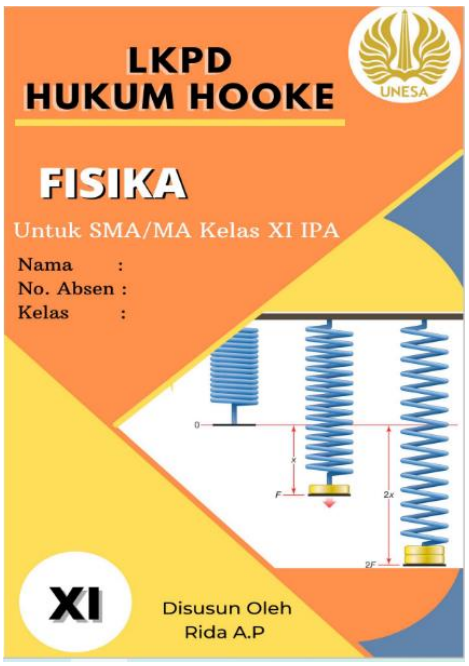

Figure 2. Cover of student worksheets

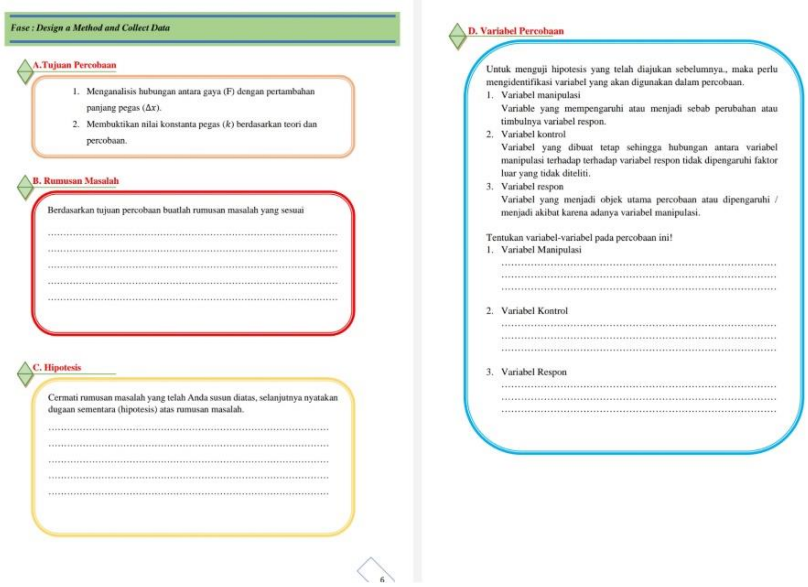

Figure 3. Designing experiments of student worksheets

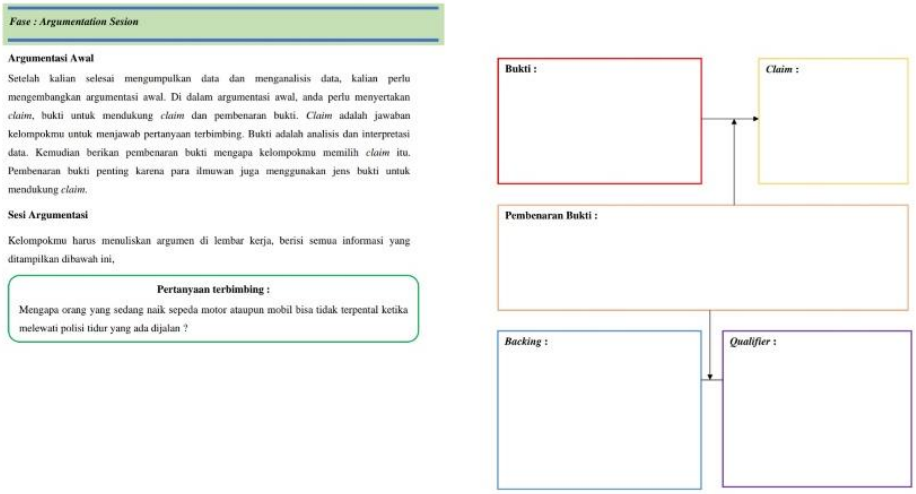

Figure 4. Argumentation sesion of student worksheets

After the product is developed, it is consulted with material expert lecturers and media experts to get input and suggestions. After that, the research instrument was revised based on the input and suggestions given. Student worksheets that have been made are then developed as expected through a validation process to determine the validity of the product. A validity test is conducted before the student worksheets are used in learning. After the research instrument was revised, the research instrument was validated by 2 lecturer. The validator in this study was a Physics Lecturer at the State University of Surabaya. The following are the results of the validation of student worksheets based on the ADI learning model:

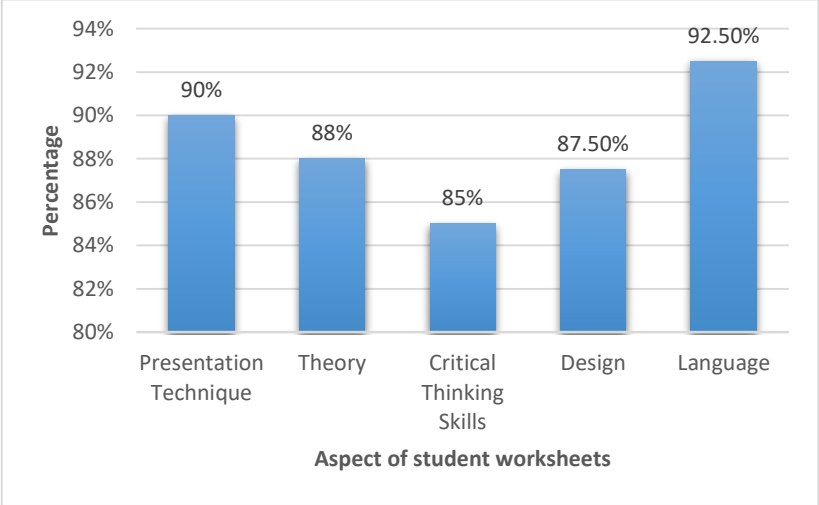

Figure 5. Student worksheets validation results

Figure 5 shows the results of student worksheet validation, divided into five aspects of assessment in student worksheets, namely, presentation technique, theory, critical thinking skills, design, and language. Through this phase, the developed products get suggestions and input from the validator. The validation results have an average score of 88.6%. This score shows that the student worksheets based on the ADI learning model developed by the researchers have valid criteria and are compatible for use in learning. This study is relevant to the results of Septiaahmad et al., (2020) which is about the development of ethnoscience-based physics student worksheets with the Discovery Learning model that was developed already valid with a total percentage of validity test, which is 88.4% in the very good category. This shows that student worksheets can be used as a medium for active learning and can direct students to solve physics problems.

In the implementation phase, at this stage, the researcher tested student worksheets and learning instuments that had been validated in class XI Mathematics and Naturan Science 4 at SMAN 18 Surabaya. Before learning begins, students will be given a pretest. Then the researcher will conduct learning using student worksheets based on the ADI learning model. After learning is done, students will be given a post-test to determine the effectiveness of student worksheets. It can be known and measured by improving students' critical thinking skills through pretest and posttest questions. The test questions refers to indicators of critical thinking skills. After being given the post-test questions, students will be given a response questionnaire to determine the practicality of the student worksheets used.

Evaluation phase: At this stage, the researcher processes and analyzes the data obtained from the implementation phase, namely the pretest and posttest student response questionnaires. Bellow is the results of the students' pretest and post-test for each question:

Figure 6. Average pretest and post-test results for each question

Figure 6 shows a diagram of the average results of each question's pretest and post-test scores. Each question has a different maximum score. Questions number 1 and 4 have a maximum score of 15, questions number 2 and 3 have a maximum score of 20, and question number 5 have a maximum score of 30. We know that each pretest and post-test questions have different improvements based on the diagram. Bellow is the average of the students' pretest and post-test results:

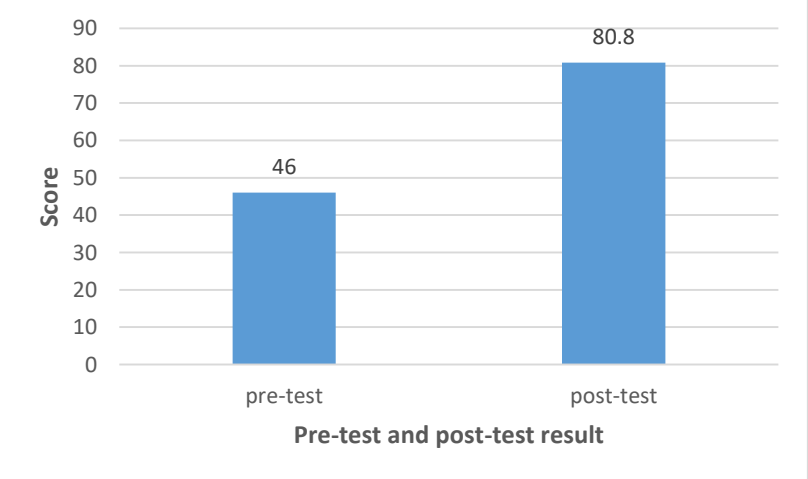

Figure 7. Average Pretest and Post-test Results

Based on Figure 7 above, it is found the average results of the pretest and post-test of students, and we can see that the average result of the pre-test is 46, and the post-test is 80.8.

This is shows that there is an increase in the result of the test. The average value is analyzed using the standard gain formula so that the N-gain calculation is 0.64. The results of standard gain in the medium category. This study, it was found that the development of student worksheets using the ADI learning model could improve students' critical thinking skills. This is because critical thinking skills also have a relationship with argumentation. In addition to setting strategies and tactics, another critical thinking indicator is to provide simple explanations. One of its sub-aspects is analyzing arguments. The indicators of analyzing arguments are identifying the reasons stated or not and looking for the structure of an argument. So, it can be said that if someone has good critical thinking skills, they will have good problem solving and argumentation skills (Nufus et al., 2018). This result is relevant to research conducted by Nurisyani, (2019)which states that there is an increase in students' critical thinking skills after the Argument-Driven Inquiry (ADI) learning model is applied to work and energy materials dengan nilai standard gain 0.74 dalam kategori tinggi.

Next is the researcher asked students to fill out a student response questionnaire to determine the practicality of student worksheets based on the ADI learning model. The response questionnaire provided consisted of 3 aspects namely: attractiveness, easiness, and usefulness. From the results of the distributed questionnaires, it was found that students' assessments of the development of student worksheets were as follows:

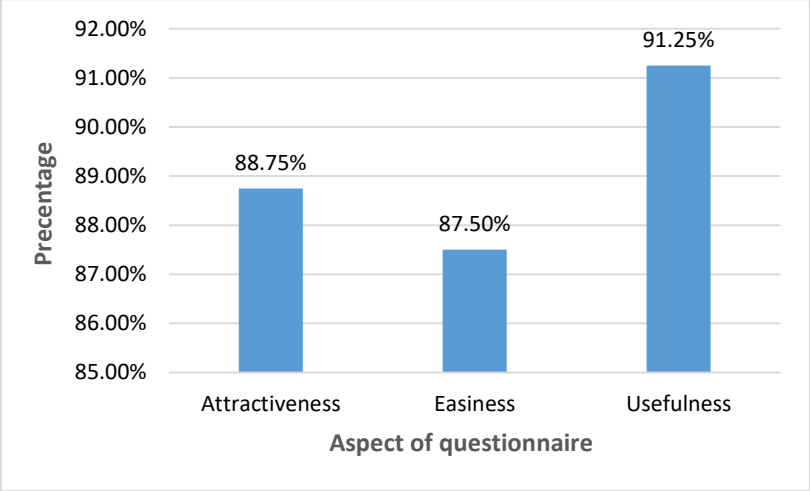

Figure 8. Student Response Questionnaire Results

Based on Figure 8 above, it is found results of the student response questionnaire, which consists of 3 aspects, namely attractiveness, easiness and usefulness. In the aspect of attractiveness, the results obtained are 88.75% with a very practice category. This acquisition shows that the presentation design of the student worksheets has an attraction for students. In the aspect of ease, the results obtained are 87.50% in the very practice category. This acquisition shows that the instructions for using the student worksheets are easy for students to understand and the selection of fonts, sizes, and spaces makes it easier for students to read the student worksheets. In the usefulness aspect, the results obtained are 91.25% with a very practice category. The acquisition of this score indicates that the student worksheets based on the Argument-Driven Inquiry (ADI) learning model has several benefits, including students being able to understand Hooke's Law material, improve students' critical thinking skills and being more motivated in learning. Follow learning. From the results of the response questionnaire above, the average score of the student response questionnaire is 89.16%, with a very practice category which indicates that development and learning using the ADI learning model has a positive meaning. In this study, it was found that the development of student worksheets based on the ADI learning model made learning more interesting and not boring. According to Calesta et al., (2021) student Worksheets are one of the learning media that can be used to assist students in adding information about the concepts studied through

systematic learning activities and helping students to be more interested in learning. This is relevant to the research conducted by Aldila et al., (2017) it was found that those who gave a positive response to the learning carried out by educators showed that the contents of the student worksheets developed were interesting and made it easier for students to understand the material and increase learning independence. and student activity.

CONCLUSION

Based on the description of the results of the analysis and discussion of the research above, it can be concluded that: (1) the results of the validation of the average student worksheets of the Argument-Driven Inquiry learning model on Hooke's Law material to practice students' critical thinking skills are 88.6% with a valid category; (2) the average results of the students' pre-test and post-test were 46 and 80.8. The n-gain value is 0.64 in the medium category; (3) the results of the student response questionnaire were 89.16% with a very practice category. These results show that the development of student worksheets based on ADI learning model on Hooke's Law material to practice students' critical thinking skills that have been developed is valid, effective and practice.

RECOMMENDATION

When conducting research, developing student worksheets based on the Argument-Driven Inquiry (ADI) learning model can be tested on a wide scale. It can manage time as effectively as possible during the research process.

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