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Development of Student Worksheets Based Inquiry using PhET Simulations to Enhance the Curiosity Attitude of High School Students

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ABSTRACT

The research aims to develop inquiry-based worksheets which are expected to increase students' curiosity about gas kinetic theory material. The inquiry approach method was developed with steps, giving problems, formulating problems, hypotheses, experiments, collecting data, analyzing data, and making conclusions. The method used is the ADDIE development method, which analyzes, designs, develops, implements, and evaluates. Developing inquiry-based worksheets and testing the effectiveness of these worksheets in the learning process. The research subjects were 22 class XI students of SMA N 4 Sijunjung. The instrument used was a student worksheet and a curiosity attitude questionnaire. Assessment of the student worksheet was carried out by validation tests of media experts, material experts, and questionnaires for teachers. The validation results of media experts showed 92.30% (very good), and media experts scored 90.21% (very good), while trials on teachers and students showed scores of 86.13% and 89.16% (very good). The results of the student worksheet effectiveness test used the medium criterion N-Gain test, value <g> 0.32. This shows that inquiry-based worksheets equipped with Phet simulations deserve to be good teaching materials and can increase students' curiosity in high school physics learning on the kinetic theory of gases.

Keywords: student worksheet development, inquiry, curiosity attitude, phet simulation

INTRODUCTION

The success of learning is largely determined by the design of teaching materials and the methods used in the learning process. In the learning process, it is very important that the name of the syllabus, learning implementation plans, teaching materials, or learning media and assessments. All of that aims to achieve effective and conducive learning outcomes and improve students' scientific attitudes toward learning outcomes.

Instructional media guides used by students to obtain information in the learning process are made in the form of student worksheet-based inquiry. Student worksheet contains instructions for students to carry out activities in a structured manner (Wulandari et al., 2017). The preparation of student worksheets is based on the characteristics of the curriculum, materials, and students' cognitive abilities, and the student worksheet instills a

high curiosity in students. The character of curiosity is highly important in the learning process, as expressed by Ardiyanto (2013), who states that curiosity will make students become active thinkers and observers, thereby motivating them to delve deeper into the subject matter. This, in turn, leads to personal satisfaction and eliminates the feeling of boredom in their continuous learning journey.

From a needs analysis for learning media where teachers must have a strategy to answer all the challenges of the problems faced by teachers and students. Therefore it is necessary the efforts to improve by the teacher so that students have a high interest in learning and have a curiosity in learning, especially physics lessons.

By looking at the current conditions, teachers and researchers are required to make improvements and choose strategies that are suitable for use in the teaching and learning process. The strategy chosen must involve students actively to arouse students curiosity. Strategies and methods that are well used and suitable for increasing students' curiosity are inquiry methods by giving student worksheets to students in the learning process.

The inquiry method is closely related to physics learning in increasing students' curiosity. This is because the inquiry method emphasizes the active role of students to find problems, formulating problems, formulate hypotheses, collect data, analyze, and make conclusions. From the explanation of the background starting from the analysis of needs, problems found in schools, researchers are interested in developing learning media with an inquiry approach to increase curiosity in high school students (Laelasari & Adisendjaja, 2018; Sari & Lahade, 2022).

Problem of Research

Based on the needs analysis conducted through questionnaires, interviews with teachers and students, and identifying the problems in schools, the frequently encountered issue is the dominant use of lecture-based teaching by teachers. The needs analysis involved distributing questionnaires to 10 teachers from two schools, where 70% of them still use the lecture method, while the remaining 30% use other methods that are rarely implemented. Considering this situation, teachers and researchers are required to make improvements and select suitable strategies for the teaching and learning process. The chosen strategy should actively engage students and stimulate their curiosity (Apriyana et al., 2019). An effective strategy and method for enhancing students' curiosity is the inquiry method, which involves providing students with worksheets during the learning process, utilizing PhET simulations.

Research Focus

Based on the background above, the focus of the research to be carried out is making student worksheets with an inquiry approach, to increase students' curiosity in high school physics learning. Physics material that will be used as a topic of gas kinetic theory research in class XI semester 2.

METHODOLOGY OF RESEARCH

General Background of Research

Inquiry-based student worksheet is designed to improve students' scientific attitude so that they are capable and skilled in solving a given problem in the learning process of physics concepts, and does not cover the areas of life in society. Through the inquiry model approach. This research is research on the development of physics worksheets on kinetic gas theory with an inquiry approach designed to increase curiosity. The development model that will be used for research to develop worksheets is the ADDIE model. The focus of this research is: Developing material physics worksheets on the kinetic theory of gasses with an inquiry approach that is specifically designed to increase curiosity. The research location was carried out at SMAN 4 Sijunjung and the research time was January 2021 until completion.

Subject of Research

The subjects used in this study were to try out students' worksheets in small groups, namely 22 high school students in class XI in semester 2 of learning.

Instrument and Procedures

This type of research is development research using mixed methods, namely qualitative and quantitative. This type of research is development research that utilizes a mixed methods approach, namely qualitative and quantitative. The instruments used involve distributing questionnaires to both teachers and students. Students will use inquiry-based student worksheets. Students are asked to then provide suggestions and opinions after using the student worksheet. Based on the input from this small group tryout, the student worksheet will be revised again. In the large group tryout, the revised student worksheet from the results of the small group tryout will be tried out in a large group with a total of 22 students. This trial was carried out when in class (experimental) after a curious attitude test was carried out. In this test it is better to direct the teacher from the school, this is useful for obtaining objective results and then becomes evaluation material so that the product is perfected.

This research development model refers to Lee & Owens (2004), namely ADDIE (Analyze, Design, Development, Implementation, and Evaluation). The flowchart of the stages of this development research can be seen in Figure 1.

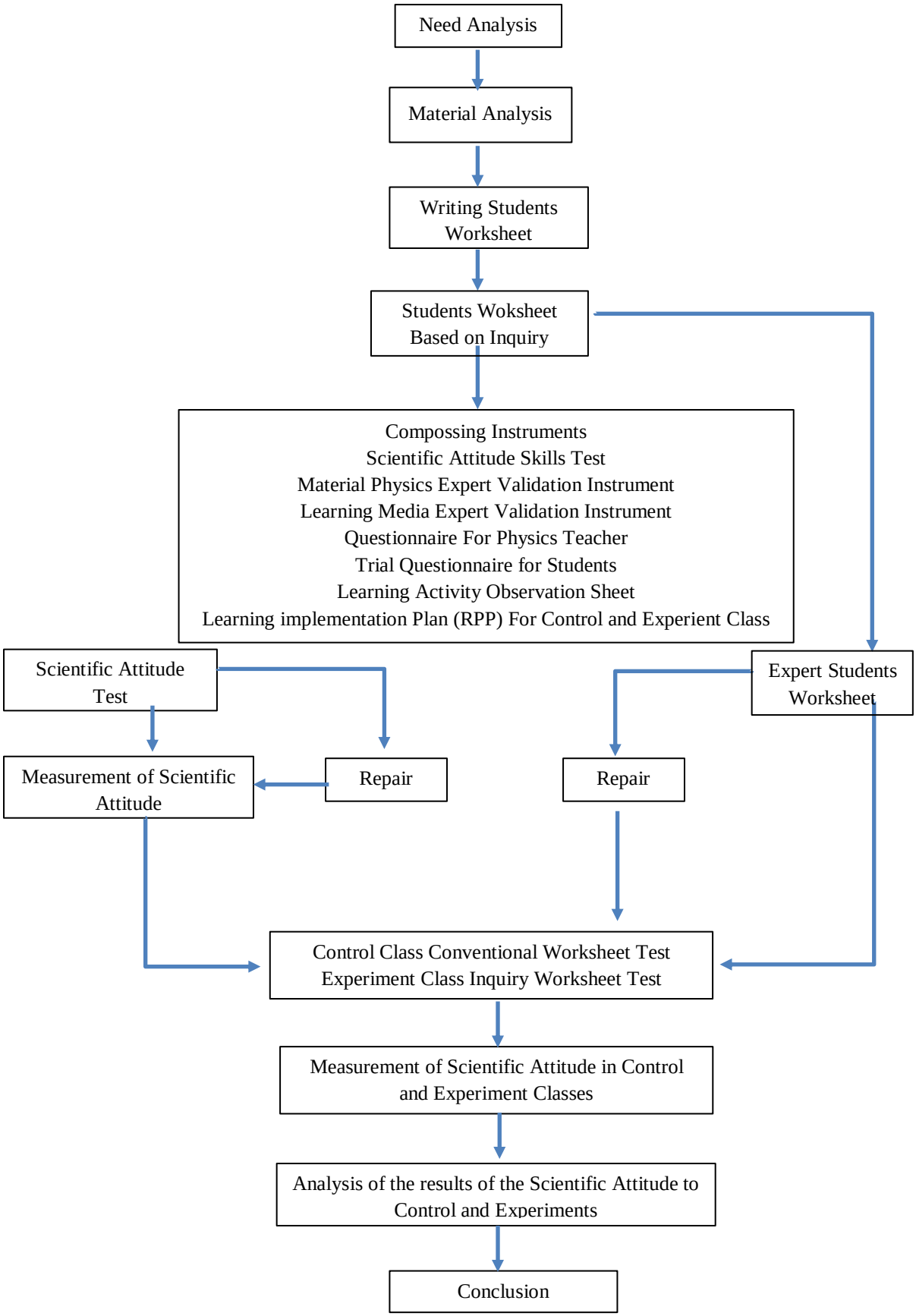

Figure 1. The flowchart of the stages of development research

The analysis phase is carried out to find out the potential problems that exist in schools through interviews and filling out questionnaires to teachers and students. The design phase is carried out to create a student worksheet framework that is developed based on the indicators to be achieved. This stage produces draft 1, namely guided inquiry-based worksheets. The development stage tested the validity of two physics teachers. The validity test was carried out by filling out a material expert and design expert test questionnaire. The scoring criteria in the questionnaire used a Likert scale adapted from Ratumanan & Laurent (2011). Each questionnaire consists of four answer choices consisting of (1) invalid, (2) less valid, (3) valid, and (4) very valid. In the implementation phase, practicality and effectiveness tests were carried out using two classes, namely experimental class one (A) and experimental class two (B) with 22 students in each class.

The practicality test was carried out by filling out a readability test questionnaire. The effectiveness test was carried out by filling in the pretest and posttest questions. The evaluation phase can be carried out at any of the four stages above which aims to measure the feasibility of the developed student worksheet. The data collection instruments used were interview guides and questionnaires. The technique of analyzing data from interviews using descriptive analysis techniques, namely by narrating the results of the interviews.

Student worksheet development starts from the analysis stage, and surveys schools and teachers to find out the learning media used in schools or those used by teachers. In a literature study, it is done by looking for information in the form of journals. The information obtained about the strengths and weaknesses of existing worksheets can be analyzed and used as a reference for developing and designing worksheets. The second stage is planning or design, at this stage an analysis of the curriculum used, the material to be appointed, student abilities, student worksheet components and determines the suitable method to be used in the student worksheet and drafts the student worksheet. The third stage is the development stage, at this stage the student worksheet is ready to be validated by material experts, and media experts. The results of the validation in the form of suggestions and criticisms from the validator can be used for the revision of worksheets that have been made and declared fit for use.

The fourth stage is the trial or implementation stage. At this stage, worksheets that are suitable for use are tested on teachers and small groups of students. There are suggestions and criticisms from all of which can be used as revisions to the student worksheet. Revised worksheets can be used in the large group trial phase. The final stage is the evaluation or assessment stage, namely the stage of assessing what students get after using the student worksheet and knowing the practicality of using the student worksheet that has been made. At this stage, worksheets that are suitable for use are tested on teachers and small groups of students. There are suggestions and criticisms from all of which can be used as revisions to the student worksheet. Revised worksheets can be used in the large group trial phase. The final stage is the evaluation or assessment stage, namely the stage of assessing what students get after using the student worksheet and knowing the practicality of using the student worksheet that has been made. At this stage, worksheets that are suitable for use are tested on teachers and small groups of students. There are suggestions and criticisms from all of which

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Data Analysis

The data collection involved conducting a validity test by completing a questionnaire on expert assessment of content and media. The questionnaire scoring criteria used a Likert scale adapted from Ratumanan & Laurent (2011). The implementation phase involved practicality testing and effectiveness testing using two classes, namely, Experimental Class One (A) and Experimental Class Two (B), consisting of 22 students in each class. The validity test was conducted by completing a questionnaire on expert assessment of content and media. The effectiveness test was conducted by completing pretest and posttest questions. The evaluation phase can be carried out at each of the four stages mentioned above, aiming to measure the suitability of the developed Student Worksheet. The improvement in students' curiosity attitude can be observed by calculating the n-gain value based on the pretest and posttest scores using the formula:

$$\text{N-gain} = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score}$$

The calculation results of N-Gain are then interpreted using the criteria by Hake (2002, p. 3), as shown in Table 1.

Table 1. Criteria for Interpreting N-Gain

N-gain	Interpretation Criteria
N-gain > 0.7	High
0.3 ≤ N-gain≤ 0.7	Medium
N-gain < 0.3	Low

The validity test was conducted by completing a questionnaire administered to subject matter experts and design experts. The scoring criteria for the questionnaire used a Likert scale adapted from Ratumanan & Laurent (2011). Criteria for the results of the questionnaire distribution for the student worksheet can be seen in the description below:
0% - 25%: Very unfavorable
51% - 75% : Good
25% - 50% : Not good
76% - 100% : Very Good

RESULTS AND DISCUSSION

The results of the validity of the media experts can be seen in the following tables:

Table 2. Evaluation Results of Media Experts

Assessment Aspects	Average Score Percentage	Interpretation
Physical View	83.33%	Very good
Language and writing	84.29%	Very good
Media Use	85.00%	Very good
Media Organization	77.50%	Very good
Average	**82.53%**	**Very good**

Based on the results of the media expert test, the average percentage of ratings given by media experts is 82.53%. This shows that the inquiry-based worksheets equipped with phet simulations were developed in terms of physical appearance, language and writing, media use, and media organization which showed very good interpretations.

Material experts are given a questionnaire to evaluate inquiry-based worksheets to get an appropriate worksheet with the material provided. Based on the data recapitulation, the results of the material expert's evaluation questionnaire are as follows:

Table 3. The Results of The Validation of The Material Expert's Physics

Assessment Aspects	Average Score Percentage	Interpretation
The suitability of the media with the curriculum	88,00%	Very good
Material accuracy	95,71%	Very good
Breadth of concept	90,00%	Very good
Average	**91.23%**	**Very good**

Based on the results of the material expert test, the average percentage of the assessment given by material experts is 91.23%. This shows that the inquiry-based student worksheet is equipped with a phet simulation which was developed in terms of the suitability of the media with the curriculum, the accuracy of the material, and the breadth of the concept has a very good interpretation.

In this pilot test on teachers, researchers used the opinion of experts on whether or not teachers should be involved in research, it turned out that the teacher's opinion was needed, even though the teacher was not the object of study, the teacher contributed to the research. The teachers involved were two physics teachers who were members of a physics teacher group. Based on the data recapitulation, the results of the physics teacher's validation are as follows:

Table 4. Results of the Teacher Trial Evaluation

Assessment Aspects	Average Score Percentage	Interpretation
Physical view	90.00%	Very good
Language and writing	91.43%	Very good
Media use	90.00%	Very good
Inquiry method	85.00%	Very good
Media organization	88.57%	Very good
The suitability of the media with the curriculum	82.00%	Very good
Execution	85.00%	Very good
Average	**87.45%**	**Very good**

Based on the results of the material expert test, the average percentage of the assessment given to teachers is 87.43%. This shows that inquiry-based worksheets are equipped with phet simulations which are developed in terms of aspects, physical appearance, language and writing, use of media, inquiry methods, media organization, conformity with the curriculum, and implementation showing very good interpretation.

The field trial was to find out students' assessments on inquiry-based worksheets equipped with phet simulations after being revised based on the validation results of media experts, subject matter experts, and teachers. The expected information is not only about the quality of the student worksheet but also what if the student worksheet is used as teaching material in learning activities. Field trials were carried out by 22 class XI students of SMA Negeri 4 Sijunjung. Based on the data recapitulation of field trial results, it can be seen as follows:

Table 5. Evaluation Results for Students

Assessment Aspects	Average Score Percentage	Interpretation
Physical view	87,90%	Very good
Legibility	86,80%	Very good
Media use	89,80%	Very good
Language	88,50%	Very good
Media organization	92,80%	Very good
Average	**89,16%**	**Very good**

The effectiveness of worksheets in increasing curiosity can be seen in how students do and speak when doing experiments. An increase in the attitude of curiosity was obtained before and after distributing the questionnaire on the attitude of curiosity. To find out the effectiveness of using printed teaching materials in the form of inquiry-based worksheets equipped with Phet simulations, the Normalized Gain (N-Gain) calculation is used. The results of the N-Gain <g> calculation in the experimental class can be seen in the table 6 below:

Table 6. Results of the N-Gain Test in the Experimental Class

Class	Pretest Average	Posttest average	<g>	Criteria
Experiment	66,83	75,53	0,32	Currently

Based on the pre-test and post-test average score data in the experimental class, a normalized gain value <g> of 0.32 was obtained. This value is then interpreted into a medium <g> value criterion. After interpretation, it was found that the effectiveness of using printed teaching materials in the form of inquiry-based student worksheets equipped with the developed Phet simulation had moderate criteria. Based on these results it can be concluded that there was an increase in the attitude of curiosity of students who used inquiry-based student worksheet teaching materials.

The evaluation results from media experts, and material experts, obtained good data validity, where the average statement raised in this study shows a validity value, this shows that the data from this statement can be understood and interpreted by students so that the student worksheet media contributes to the emergence of an attitude of curiosity know from students. So that students can better understand the meaning and intent.

From the percentage level obtained from media and material experts, the average percentage was 82.53%, and from material experts 91.23%. The results of the due diligence on experts and users obtained an overall average percentage of 85.58% with a very good interpretation. This shows that the Inquiry-based student worksheet media is suitable for use in physics learning. Media that is suitable for use is then tested on users to find out whether the student worksheet media can increase students' curiosity.

The results of the assessment of the questionnaire given to students showed that from various aspects of the student worksheet media, it gave an average percentage of 81.16%, and the results of the questionnaire on students' curiosity were obtained by using inquiry-based student worksheet media to increase the attitude of curiosity easily and could well used.

Based on the average percentage of all validators from media experts, material experts, high school physics teachers, and students who were given the questionnaires given, it shows that all aspects of the inquiry-based student worksheet are very good and so this student worksheet media is feasible to use and develop in learning to high school students in the field of physics studies.

In the Inquiry-based student worksheet media with Phet simulation, it is designed to increase students' curiosity, so that students are more confident and instill character values in learning physics in carrying out the practicum given. This student worksheet is made very simple with easy-to-understand guides in carrying out practicums using Phet simulations when running them.

The inhibiting factor in the implementation of student worksheet media was detected during trials on students, students were less careful in reading instructions for using student worksheet media and inquiry instructions so they spent quite a long time using student worksheet media. This is because students do not know what to fill in at a certain step. This is minimized by giving examples of how to use inquiry in a problem. The example is delivered directly to students before students use the media at the beginning of the meeting.

The effect of giving these examples is that students have an initial picture of how to apply inquiry to student worksheet media and start reading the instructions for using student worksheet media more thoroughly and don't ask again at the next meeting so that an attitude of curiosity can be well developed within the scope of SMA N 4 Sijunjung students.

From the analysis of the N-Gain test conducted, it was found that there was an increase in the curiosity attitude of students with moderate criteria. It can be concluded that the inquiry-based student worksheet media with Phet simulation provides an increase in the curiosity attitude of students.

The results of this study are also supported by data that align with the findings of research conducted by Damayanti et al (2013). Their study focused on the development of student worksheets using the guided inquiry approach to enhance students' critical thinking skills in the context of dynamic electricity in SMA Negeri 3 Purworejo during the academic year 2012/2013. Their findings demonstrated that the development of Student Worksheets made a positive contribution to optimizing critical thinking abilities within the Guided Inquiry Approach system.

Based on the above description, it can be observed that instructional materials can be developed by teachers according to students' needs. The effectiveness of inquiry-based student worksheets aligns with the results. The use of worksheets in physics education has several advantages, including improving students' learning outcomes (Fauziah & Fathiah, 2016; Indrasati, 2016; Abelta et al., 2017), enhancing students' learning motivation (Indrasati, 2016; Prasetyawati et al., 2019), developing higher-order thinking skills in students (Purnamawati et al., 2017; Fitriani et al., 2017), improving conceptual understanding (Abelta et al., 2017; Barlenti et al., 2017) and the participants' curiosity towards the subject matter, especially in physics, is considered good. The character curiosity is an attitude and behavior that constantly strives to gain a deeper and broader understanding of something being learned, seen, and heard (Novelyya, 2019). These advantages make worksheets considered as media and teaching material that can actively engage students in the learning process while acknowledging the important role of the teacher as a facilitator and motivator in the classroom.

Based on the description above, starting from the calculation results of the validation of the two experts, teachers, and students for the student worksheet trials and the results of the curiosity attitude questionnaire that inquiry-based physics student worksheet is acceptable and can increase students' curiosity, so it is suitable for use as teaching material by students High school in class XI gas kinetic theory material.

CONCLUSIONS

Student worksheets-based inquiry using phet simulations that are developed are suitable for use as high school physics learning media. Based on the average percentage of all validators from media experts, material experts, high school physics teachers, and students who were given a questionnaire, it showed that all aspects of inquiry-based worksheets using phet simulation obtained very good criteria. This students worksheet is designed to increase

students' curiosity so that students are more confident and instill character values in physics learning in carrying out the given practicum. Based on the analysis of the N-Gain test, it was found that inquiry-based student worksheets with Phet simulations increased students' curiosity. For future researchers who examine the same problem, they should choose a material that is more comprehensive so that students' curiosity and understanding are better.

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