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Development of Student Worksheets Based on a Scientific Approach to Colloidal System Material

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Abstract
The purpose of this study was to determine the feasibility of developing student worksheets based on a scientific approach, student responses and teacher responses to the developed student worksheets. The type of research used was research and development with a 4D model. The instruments used in this study were validation sheets and response questionnaires. Before the field trial was conducted, the student worksheets were validated by a team of experts to determine the shortcomings of the student worksheets, then revised and tested. The results showed that the average percentage obtained from the media expert validator was 80.66%, material experts 85.33%, and language experts 82.66%, with an average percentage of 82.88%, this indicates that the student worksheets can be used with feasible criteria. The percentage obtained from the results of student responses was 34% very interested, 55% interested, and 11% less interested. The percentage of teacher response results was 25% very interested, 65% interested, and 10% less interested, this shows that the student worksheets developed can be used in State Islamic High School 5, Aceh Besar. Research on the development of student worksheets based on a scientific approach to colloidal system material offers innovation in more interactive learning, encourages conceptual understanding through exploration and experimentation, and improves students' critical thinking skills.

Keywords: Colloidal System, Scientific Approach, Student Worksheet

INTRODUCTION

Education is all efforts and all attempts to make society able to develop the potential of students to have spiritual religious strength, self-control, personality, have intelligence, have noble morals, and have the skills needed as members of society and citizens (Marsya, 2024; Mursyid, 2022). In education, teaching and learning activities occur between students and educators. Therefore, it is necessary to renew education so that it does not fail (Abnisa & Zubairi, 2022). Failure in education can reflect the failure of a country, and vice versa, success in education can bring success to a nation. Education as a conscious and planned effort that aims to educate the life of the nation, education will be formed with the learning process (Khaidir & Suud, 2020).

Chemistry is a branch of natural science that is taught from high school level (Kanwal et al., 2022;

Upahi et al., 2020). It aims to make students understand chemical concepts and their good applications in everyday life and technology, and be able to apply chemical concepts to solve problems in everyday life and technology scientifically. Chemistry also uses a number of supporting methods in its learning practices so that they can be absorbed and understood (Wang & Ren, 2020). This is important, because some students consider chemistry to be a difficult subject to understand, such as physics and mathematics. Therefore, it is important for teachers to know and apply learning using appropriate and enjoyable methods.

Student worksheets are the best means to develop science process skills because learning using student worksheets can provide opportunities for students to understand or work on existing problems (Haryadi & Pujiastuti, 2020; Katauhi et al., 2022). Learning using student worksheets is an important part that cannot be separated from teaching and learning activities in chemistry learning (Yalyn et al., 2022). Learning with student worksheets is a learning method that can be used to provide science process skills to students (Mutlu, 2020; Patresia et al., 2020).

This shows how important the role of student worksheets is in achieving learning objectives. So far, student worksheets implemented in schools are still verification in nature, namely only proving concepts or principles that have been learned. Student worksheets contain a set of basic activities that must be carried out by students to maximize understanding in an effort to form basic abilities according to the indicators of learning outcomes that must be taken (Muskita & Subali, 2020). Student worksheets are a collection of sheets containing activities that will be carried out by students in learning (Widyaningrum & Prihastari, 2020). The activities experienced by students vary widely, ranging from finding problems, designing experiments, formulating hypotheses, compiling theoretical bases, conducting experiments, collecting data, analyzing data, conducting discussions, and concluding.

One of the difficult materials to understand is the colloid system. Colloid system material is contextual material. Colloid systems explain the types of colloids that are directly involved in students' lives such as hydrophilic colloids, hydrophobic colloids, other examples such as milk, coconut milk, and so on (Handayani et al., 2020). However, in chemistry learning, colloid material tends to be memorized by students so that it can cause several misconceptions, including students assuming that solutions are mixtures of a substance with water, solutions are always dilute, and colloids are always thick, colloids precipitate, colloids are solid, solutions are always liquid, and solutions are mixtures of a material with water. Therefore, an alternative is needed in the form of learning based on a scientific approach with the help of student worksheets on the colloid system material. Through learning with a scientific approach, it is hoped that students will have the ability to explore information through observing, asking, trying, reasoning, and communicating activities.

Previous research conducted by Silaban et al., (2022) Previous research focused more on the development of electronic modules aimed at improving students' scientific literacy. The module integrates technology with literacy skills, so that students can understand colloid material independently and contextually. However, these studies tend to be individual and centered on the use of technology as a learning medium. Meanwhile, the current study emphasizes the development of student worksheets based on a scientific approach that prioritizes direct, collaborative, and exploratory activities in understanding the concept of colloids. The gap that is seen is the focus of the approach; previous studies focused more on scientific literacy through digital media, while the current study emphasizes the active learning process through worksheets as a tool for scientific exploration in the classroom.

The novelty of this research lies in the application of a structured scientific approach in student worksheets, which allows students to be actively involved in exploring and solving real problems related to colloidal systems. This approach encourages critical, analytical, and collaborative thinking skills, which are very important in modern science learning. The urgency of this research is driven by the need for more interactive and contextual teaching materials, considering that conventional teaching methods are often less effective in stimulating deep understanding and active involvement of students. With the existence of worksheets based on a scientific approach, it is expected to improve the quality of learning and improve student learning outcomes, especially in understanding abstract concepts such as colloidal systems. Based on the background above, the purpose of this study is to determine the feasibility of

developing student worksheets based on a scientific approach, student responses and teacher responses to the student worksheets developed.

RESEARCH METHODS

Research Design

The type of research used is research and development (R&D). The research and development method is a process or steps to develop a new product, or improve an existing product, which can be accounted for (Morgan & Liker, 2020). The device development model used in this study is the Four-D model developed by Thiagarajan. The stages of 4-D development are the definition stage, design stage, development stage, and distribution stage (Lubis et al., 2021; Mahsunah & Shobah, 2022).

Research Subject

The population in this study were all students of class XII of State Islamic Senior High School 5 Aceh Besar. The sample in this study was 20 students of Class XII IPA 1 of State Islamic Senior High School 5 Aceh Besar. The technique used for sampling was the simple random sampling technique or what is commonly called the simple random technique. The simple random sampling technique is carried out by taking samples or elements randomly, either by lottery, and so on without considering the strata or levels in the population, where each element or member of the population has the same opportunity to be selected as a sample (Akkaş & Meydan, 2024).

Instruments, and Data Collection Techniques

In this study, the data collection instruments used were validation sheets and response questionnaires. Before being used, the instrument must be validated first. The validity of an instrument is the level of suitability of the measuring instrument with certain criteria. An instrument is said to have high validity or is valid if the instrument is in accordance with the criteria (Sember et al., 2020). After being validated, the questionnaire can be used to see the responses of students and teachers to student worksheets based on a scientific approach. In this study, questionnaires were given to teachers and students to obtain data on teacher and student responses to the development of student worksheets based on a scientific approach. The questionnaire used was a checklist with a scale of 1 to 5. The scale for measuring the questionnaire used a Likert scale.

Data collection techniques are methods that can be used by researchers to collect data. Data collection is one of the most important stages in research (Karunarathna et al., 2024; Mazhar et al., 2021). The correct data collection technique will produce data that has high credibility. The data collection techniques used in this study are validation sheets and questionnaires.

Data analysis technique

The suitability of a student's worksheet is determined by the suitability of the validation results with the specified validity criteria. The total amount of validity is then calculated as a percentage using the following formula:

$$scor(\%) = \frac{number\ of\ validation\ component\ scores}{maximum\ score}\ x\ 100\%$$

After that, the scores (%) that have been produced are discussed in the form of a criteria table which is presented in the following table:

Table 1. Student Worksheet Validation Assessment

Percentage %	Description	Number
85-100%	Very worthy	5
70-85%	Worthy	4
50-70%	Less worthy	3

15-50%	Not worthy	2
<15%	Very unworthy	1

The data analysis process for student and teacher questionnaires on student worksheets with a scientific approach to colloidal system material distributed to students and teachers with the assessment scores used were: (1) strongly disagree, (2) disagree, (3) undecided, (4) agree, (5) strongly agree.40 The percentage of student responses can be calculated using the following equation:

$$P = \frac{F}{N}\ x\ 100$$

Description: P = percentage number F = frequency whose percentage is being sought. N = number of frequencies/number of individuals. The benchmark used to interpret the percentage of student response values can be seen in the table below:

Tabel 2. Penilaian Angket

Persentase %	Description	Number
85-100%	Very interested	5
61-80%	Interested	4
41-60%	Less interested	3
21-40%	Not interested	2
<20%	Very uninterested	1

RESULTS AND DISCUSSION

Validation Data for Student Worksheets on Colloidal Systems Material

The results of validation with the validator and the percentage obtained from the whole with the criteria can be seen in the following table:

Table 3. Validator percentage data

No	Validator	Aspect	Percentage (%)	Average	Criteria
1	Validator I		74		
2	Validator II	Construct	74	80.66%	Worthy
3	Validator III		94		
4	Validator IV		72		
5	Validator V	Content	84	85.33%	Very Worthy
6	Validator VI		100		
7	Validator VII		70		
8	Validator VIII	Language	78	82.66%	Worthy
9	Validator IX		100		
Average total score			82.88%	82.88%	Worthy

Based on the validation results from the validator, the student worksheet on the colloidal system material has been declared to be used in learning activities. The percentage of validation results obtained from validator I (construction expert) is 74%, the percentage from validator II (construction expert) is 74%, the percentage from validator III (construction expert) is 94%, the percentage from validator IV (content expert) is 72%, the percentage from validator V (content expert) is 84%, the percentage from validator VI (content expert) is 100%, the percentage from validator VII (linguist) is 70%, the percentage from validator VIII (linguist) is 78%, and the percentage from validator IX (linguist) is 100%. So the average obtained from the validation of the student worksheet is 82.88% with feasible criteria.

Teacher Response Result Data

The following is a percentage of teacher responses to student worksheets:

Table 4. Teacher Response Result Data

No	Item Scale	Percentage
1	Percentage very interested	25%
2	Percentage interested	65%
3	Percentage less interested	10%
4	Percentage not interested	0%
5	Percentage very uninterested	0%

Based on the above results, the percentage of chemistry teachers from all statement items is the number of percentages of chemistry teachers who answered very interested 25%, chemistry teachers who answered interested 65%, and chemistry teachers who answered less interested 10%. Thus, it can be concluded that student worksheets on the colloidal system material can be used in State Islamic Senior High School 5 Aceh Besar.

Student Response Result Data

The following is the percentage of student responses to student worksheets:

Table 5. Student Response Result Data

No	Item Scale	Percentage
1	Percentage very interested	34%
2	Percentage interested	55%
3	Percentage less interested	11%
4	Percentage not interested	0%
5	Percentage very uninterested	0%

Based on the table above, the results of the percentage of students from all statement items are the number of percentages of students who answered very interested 34%, students who answered interested 55%, and students who answered less interested 11%, to the statements given. Thus it can be concluded that the student worksheet on the colloidal system material can be used in the 5th State Islamic Senior High School of Aceh Besar.

This research has the potential to have a significant impact on the learning process in the classroom, especially on the topic of colloidal systems. With the presence of worksheets based on a scientific approach, students will be more actively involved in the learning process through experimental activities, observations, and analysis, which can improve understanding of concepts in greater depth. In addition, students' critical thinking skills and problem-solving abilities will also be honed. As a result, student learning outcomes in understanding abstract materials such as colloids can increase, and teachers will have more effective teaching aids and support inquiry-based learning. This research also has the potential to be adapted to other topics in science, expanding its impact in improving the quality of education.

The limitations of this study may include several aspects. First, the effectiveness of this worksheet may depend on the teacher's level of readiness to apply the scientific approach, which requires a deep understanding of the scientific method and the ability to facilitate student-centered learning. Second, the variation in students' academic backgrounds may affect the extent to which this worksheet can be optimized, especially if students have diverse basic understandings of science. In addition, the classroom environment and available resources, such as laboratory equipment or sufficient time for experiments, may also be constraints. This study may also have failed to consider the flexibility of using worksheets in online learning, which is increasingly relevant in the digital era.

CONCLUSION

The conclusion of this study is the validation results carried out by two practicing teachers to determine the teacher's response to the colloidal system student worksheet developed, this stage is carried out by providing media and validation sheets to chemistry teachers at the 5th State Islamic Senior High School in Aceh Besar, so that a percentage value of 25% is obtained with the category of very interested, 65% interested and less interested is 10%. The results of student responses are carried out to determine student responses to the colloidal system student worksheet developed. The trial was carried out by providing a student response questionnaire and the developed student worksheet to students in class XII IPA 1, with the percentage of students who chose very interested amounting to 34%, interested 55%, less interested 11%, while those who chose the criteria not interested and very not interested were none. It can be concluded that student responses to student worksheets based on a scientific approach to the colloidal system material are feasible so that they are practical to use on students. Further research is recommended to explore the effectiveness of this scientific approach-based worksheet in online and hybrid learning contexts, as well as to develop training modules for teachers to optimize the application of the scientific approach in various classroom conditions.

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