

Development of STEM-Based LKPD with Guided Inquiry Design to Improve Student's Science Process Skills

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Abstract

This study aims to develop a STEM-based Student Worksheet (LKPD) through Guided Inquiry to Improve Students' Science Process Skills. This research and development method refers to the Borg & Gall model up to the 8th stage, namely a trial use that has been adapted to research needs, namely developing LKPD and seeing an increase in students' science process skills after using LKPD in learning activities, with research subjects in class XI IPA 5 and XI. IPA 3, each totaling 24 students. The results obtained are: 1) the validation of the LKPD that has been developed is "very valid" with the percentage of material experts at 82.36% and the percentage of media experts being 82.44%; 2) the feasibility of the developed LKPD is very feasible with a percentage of 95.43%; 3) The LKPD developed is declared practical because the response questionnaires from students are categorized as practical 4) the results of students' responses to the use of "very good" trials with a percentage of 87.33%; 5) The effectiveness of LKPD is seen from the achievement of students' science process skills with an N-Gain value of 0.78 or with a percentage of 78% overall very good and increasing in every meeting. It was concluded that the development of STEM-based LKPD through Guided Inquiry was valid and feasible and could be used in the Physics learning process to improve Students' Science Process Skills on Thermodynamic Materials.

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1. Introduction

The 2013 curriculum emphasizes the scientific method of learning, which is defined as helping students recognize and comprehend various materials through a scientific method. The information does not depend on the teacher or teacher alone; it can come from anywhere. Physics is taught as a tool for everyday problem-solving and for developing scientific thinking and behavior. To solve and respond critically and scientifically to natural phenomena and events [1], students are required to comprehend and interpret the information they have gained. The laws, theories, postulates, facts, concepts, and procedures that are consistent with the scientific method can be found in the physics field [2].

The Guided Inquiry learning model [3] is the learning model that can help students improve their science process skills by the characteristics of physics learning and the curriculum of 2013. It is possible to say that guided inquiry learning can improve students' way of thinking in understanding concepts in physics learning [4]. This learning model can develop students' scientific critical thinking by placing students as learners in solving a problem and obtaining investigative knowledge so that they can understand scientific concepts.

The guided inquiry learning model can engage students' active participation in the physics learning process in class and develop students' science process skills at high, medium, and low academic abilities [5].

According to the curriculum of 2013, STEM learning is one of the learnings that emphasizes the learning process so that students can use a scientific approach to comprehend various materials [6]. STEM education is the integration of science, technology, engineering, and mathematics (STEM) education, which has been suggested to aid in the achievement of 21st-century skills [7]. Science process skills are skills that can be linked to STEM because students can learn them through the science section using STEM science process skills. Students need to have strong science process skills to be able to use the scientific method to find ideas or facts [8].

STEM is an integration between the four disciplines of science, technology, engineering, and mathematics using an interdisciplinary approach and is applied based on real-world contexts and problem-based learning [9]. STEM is an integrated learning approach that connects real-world applications with classroom learning that includes natural science (science), technology, engineering results, and mathematics [10]. STEM-based learning can improve students' science process skills in applying their knowledge to make designs as a form of problem-solving related to the environment and technology. Science process skills are a work process a person's brain is an important instrument for learning, considering, and analyzing what is good or bad [11].

Teacher teaching materials can incorporate the STEM approach in the form of LKPD. One way to facilitate teaching and learning activities so that students and teachers can interact effectively is through the Student Worksheet (LKPD). Students and educators alike may be able to overcome obstacles through the creation of STEM-based LKPD. The Lesson Plan (RPP) can be implemented using LKPD in general as a complement or support tool [12]. To help students develop their process skills, teachers should prepare worksheets for their students (LKPD). These worksheets can be used to present learning through experiments or other methods. Student activity that teaches them to put their newly acquired knowledge into practice is the Student Activity Sheet. The Student Activity Sheet plays a crucial role in assessing how well students retain and apply the information presented. The four fields of science, technology, engineering, and mathematics comprise the developed LKPD. It's the potential to enhance students' science process skills, as well as their ability to think critically and creatively in the technology, engineering, and mathematics section [13]. Thermodynamics is one of the materials that are difficult to comprehend but serves as the foundation for numerous scientific fields. The laws of thermodynamics are fundamental to everyday life and education. Teaching effective thermodynamics is essential because it is a fundamental science that must be thoroughly comprehended. Understanding the difficulties students face with the concept of thermodynamics and how the concept can be presented through the use of LKPD as educational materials is a good place to start [14].

Despite the availability of laboratory facilities in schools, physics instruction rarely makes use of practicum methods. This is even though there are numerous difficulties students face when learning physics, such as memorizing solid physics material and counting, as well as learning physics in a classroom setting that is not contextual and is not balanced with the selection of teaching materials during classroom learning activities [15]. The teacher also rarely makes connections between the material being studied and everyday concepts during the learning process. The aforementioned facts are comparable to the findings of interviews and observations conducted with physics subject teachers at one of the public schools in Lhokseumawe, SMAN Modal Bangsa Arun.

This finding shows that students do not yet understand science process skills. Additionally, the instructor stated that students had never utilized physics concepts-based STEM worksheets. According to previous research [16], the STEM integrated approach, which is based on guided inquiry on temperature and heat, was successfully utilized as teaching material. The critical thinking abilities of students can be enhanced by LKPD developed using the STEM approach. Worksheets based on STEM can be used effectively as a supporting learning resource to improve students' creative thinking skills [17].

This issue motivates researchers to develop STEM-based LKPD through Guided Inquiry to Enhance Students' Science Process Skills to carry out research. The following are the primary goals of this study to develop effective STEM-based worksheets that can enhance students' science process skills through the use of guided inquiry. This study only looks at thermodynamics material from class XI. The fact that this study examines not only the development of a product but also the improvement and efficacy, which is tested on a large scale after the product has been developed, sets it apart from previous studies. In addition, the developed LKPD is based on STEM and uses a guided inquiry model, which makes it easy for students to understand and is expected to improve students' science process skills, which is important in the 21st century learning process.

2. Method

This research using research & development (R&D) Borg and Gall model, consist of: potential problems, collecting data, designing the product, validating the design, revising the design, testing the product, revising the product, testing the use, and mass production [18]. However, the researcher in this study only restricted the research phase to the use trial phase, which was tailored to the objectives and requirements of the study.

This research on the development of LKPD was carried out at SMAN Modal Bangsa Arun in North Aceh, during the even semester of the 2021/2022 academic year. Each of the 24 students in the experimental and control classes of XI IPA 5 and XI IPA 3 received STEM-based LKPD objects through Guided Inquiry on Thermodynamics material as the research subjects. Validation and student response questionnaires were the methods of data collection used.

The results of this study include both quantitative and qualitative data. Quantitative data in the form of evaluation results and scores of responses to assessment questionnaires from experts in design, material, and physics. While the developed STEM-based worksheet responses and suggestions from material experts, design experts, physics teachers, and students comprise the qualitative data, The descriptive data analysis that was carried out in this study consisted of two types of data analysis: data analysis for the results of the validation questionnaire and data analysis for the results of the teacher questionnaire and student responses that were designed and summarized in the form of a Likert scale table for material experts, design experts, and physics teachers. The data analysis technique was divided into these two types of data analysis. Calculating the level of validity/ feasibility using percentage agreement with the equation 1.

$$P = \frac{f}{N} \times 100\% \quad (1)$$

with, P = percentage of eligibility, f = total scores of data collection result, and N = ideal score. For expert validation is then presented according to the criteria $76\% \leq P \leq 100\%$ (valid), and $0\% \leq P \leq 39\%$ (invalid) [17]. Furthermore, to find out the response of students to the LKPD developed from the LKPD, using the percentage agreement equation 1 with the same criteria.

The results of the calculation of student response questionnaires were analyzed using the assessment criteria in Table 1.

Table 1. Criteria for Percentage of Student Response Questionnaires

Percentage score (%)	Category
0 - 20%	Not good
21 - 40%	Not good
41 - 60%	Pretty good
61 - 80 %	Well
81 - 100%	Very good

3. Result and Discussion

A group of experts, including three instructors of physics education, have looked over the LKPD's results. Based on what the expert team talked about, it's hoped that the student worksheets can be used to learn thermodynamics and physics.

The outcomes of developing STEM-based worksheets has design to the thermodynamic materials and class XI students' characteristics. This STEM-based LKPD has a science section on simple thermodynamic material experiments that has been adapted to the guided inquiry syntax. The objectives of learning, problem formulation, hypothesis formulation, identifying variables, tools, and materials, as well as experimental steps, results and discussion, data analysis, and conclusions are all included in this section.

Students are required to examine how thermodynamics is applied to everyday technology in the technology section of technology, engineering, and mathematics. Students are instructed to draw or design using tools, materials, and work steps tailored to the thermodynamic material as part of engineering. Students are required to analyze the given questions in the mathematics section.

The Borg and Gall model is referred to until the eighth stage in the findings of the research on the development of STEM-Based Student Worksheets (LKPD) through Guided Inquiry. The following is a description of the outcomes that were obtained from each step of using Guided Inquiry to create STEM-based Student Worksheets (LKPD):

- a. Potential Issues: Teachers and students at SMAN Modal Bangsa Arun were interviewed and observed to determine the level of potential issues in this study.
- b. After the issue has been identified, data collection is carried out. This data serves as the basis for product planning, which is intended to address the issue. The data that was gathered consisted of information regarding teacher requirements for existing and desired teaching materials, as well as class XI physics content, particularly content on thermodynamics.
- c. The STEM-based LKPD (Science, Technology, Engineering, and Mathematics) design of thermodynamic materials for class XI SMA/MA consists of an introduction, a content section, and a conclusion. The content feasibility, linguistic, presentation, and graphic aspects of LKPD are then used to measure it.
- d. Product Design Validation, product design validation is carried out by media and material expert validators following the completion of the initial product design. On the questionnaire that the researcher has provided, validators are asked to fill it out and make suggestions regarding the quality of the materials and media used in the products that have been developed.
- e. Product Revision: The product that was developed based on the expert team's suggestions for improvement will be revised after it has been validated by material and media experts.

- f. Product Trial: The next step is a small-scale product trial. Ten students from class XII IPA 5 at SMAN Modal Bangsa Arun, who have previously studied Thermodynamics, participate in the test at this point.
- g. Product Revision: At this point, the STEM-based LKPD is revised taking into account the stage. The use trial, which is carried out on a large scale, is the subsequent stage. At this point, 24 students from the experimental class XI IPA 5 at SMAN Modal Bangsa Arun participated in the STEM-based LKPD through Guided Inquiry.

The STEM-based LKPD validation test according to material experts is based on aspects of content quality assessment, students' science process skills, presentation quality, and language quality. The results of the calculation of LKPD validation according to material experts can be seen in the [Table 2](#).

Table 2. Material Expert Validation Results Based on Assessment Aspects

No	Aspects of validity assessment	Average	Percentage %	Validity level
1	Content quality	4.25	85%	Valid
2	Students' Science Process Skills	3.70	74.44%	Valid
3	Serving Quality	4.33	86.67%	Valid
4	Language Quality	4.17	83.33%	Valid
Average amount		4.15	82.36%	Valid

[Table 2](#) shows the average results of expert's judgement of 4.15 with a percentage of 82.36% included in the valid category, which means it is feasible to use. The percentage of the total validation results by material experts on STEM-based worksheets that have been developed can be expressed by the following [Figure 1](#).

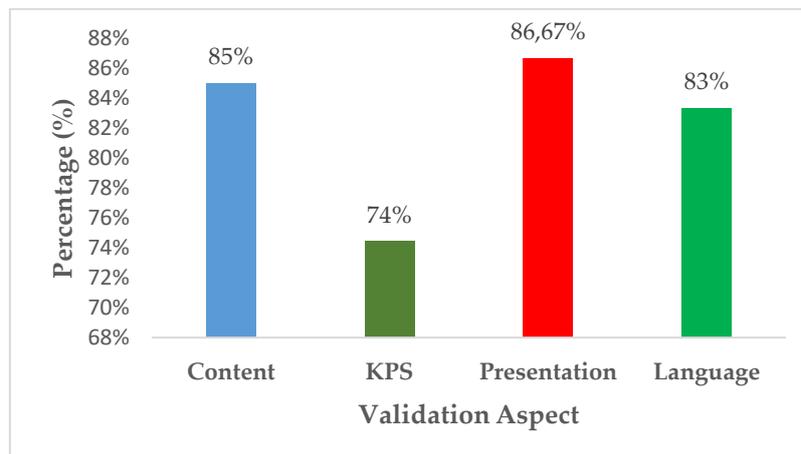


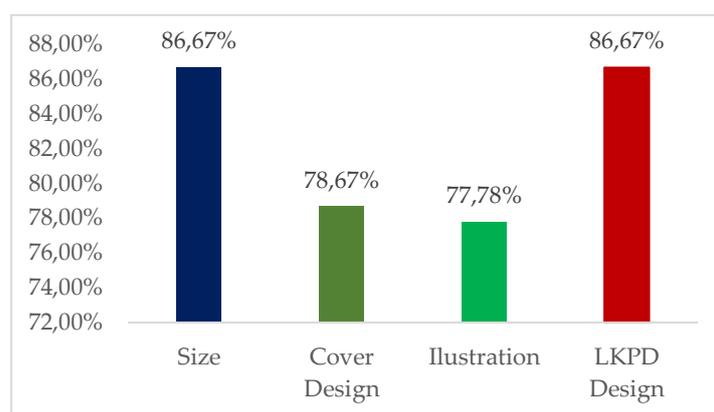
Figure 1. Expert Judgement Result

The results of the STEM-based LKPD validation according to media experts are based on aspects of LKPD size assessment, cover design, content presented by [Table 3](#).

Table 3. Media Expert Validation Results Based on Assessment Aspects

No	Aspects of validity assessment	Average	Percentage %	Validity level
1	LKPD Size	4.33	86.67%	Valid
2	Cover Design	3.93	78.67%	Valid
3	Content Illustration	3.89	77.78%	Valid
4	LKPD Design	4.33	86.67%	Valid
Average		4.12	82.44 %	Valid

Table 3 shows the average results of the media expert's assessment, which is 4.12 with a percentage of 82.44% in the valid category, which means it is feasible to use. The percentage of total expert judgement to validation results on STEM-based worksheets that have been developed can be expressed by the Figure 2.

**Figure 2.** Percentage of Result of Media Experts Judgement

This LKPD is adjusted to the competency standards and basic competencies according to the 2013 curriculum. Table 2 and Table 3 which contain the results of the validity of the LKPD show that the three aspects of the LKPD validation sheet show valid categories. It can be said that the LKPD developed is feasible to be tested, according to [18] which states that an LKPD is said to be feasible if it meets three conditions, namely didactic requirements, construction requirements, and technical requirements.

Didactic requirements are requirements related to the fulfillment of the principles of effective learning in an LKPD. Construction requirements are requirements related to language, while technical requirements are requirements related to writing based on established rules. The results of the didactic criteria aspect obtained a valid category, where this criterion was according to the didactic requirements, namely the requirements related to effective learning principles in an LKPD, this was according to what was said by [3]. Meanwhile, in the construction aspect, it obtained a valid category, which was also according to what were the requirements of the construction requirements where the language used in this STEM-based LKPD was according to the Indonesian language rules. This is according to what was stated by [8], namely that LKS must be arranged in an attractive format and design so that it is easy to read and that students can understand the activities in the LKPD.

The construction requirements in the LKPD include providing sufficient space to give students the flexibility to write answers or draw on the LKPD. The results of the validation on the LKPD developed as a whole are categorized as valid and have very high reliability.

The results of the validation on the LKPD which are categorized as valid state that the developed LKPD has met the standards of a good LKPD component, and it can be said that the developed LKPD can produce data on the achievement of students' science process skills correctly [19].

Assessment by the teacher serves to assess the appearance of the LKPD from various aspects including content quality, students' science process skills, presentation quality, linguistic quality, and LKPD appearance. The following are the results of the feasibility test from the teacher experts judgement on the LKPD presented by

Table 4.

Table 4. Feasibility Test Results by Teachers Based on Assessment Aspects

No	Aspects of validity assessment	Average	Percentage %	Validity level
1	Content Quality	5	100%	Very good
2	STUDENTS' SCIENCE PROCESS SKILLS	4.72	94.55%	Very good
3	Serving Quality	4.67	93.33%	Very good
4	Language Quality	4.75	95%	Very good
5	LKPD Display	4.71	94.25	Very good
	Average	4.76	95.42	Very good

Table 4 shows the average result of the feasibility test by the teacher, which is 4.76 with a percentage of 95.42% in the very good category, which means that it is suitable for use in schools in the learning process. The percentage of total teacher expert validation results on STEM-based LKPDs that have been developed can be expressed by Figure 3.

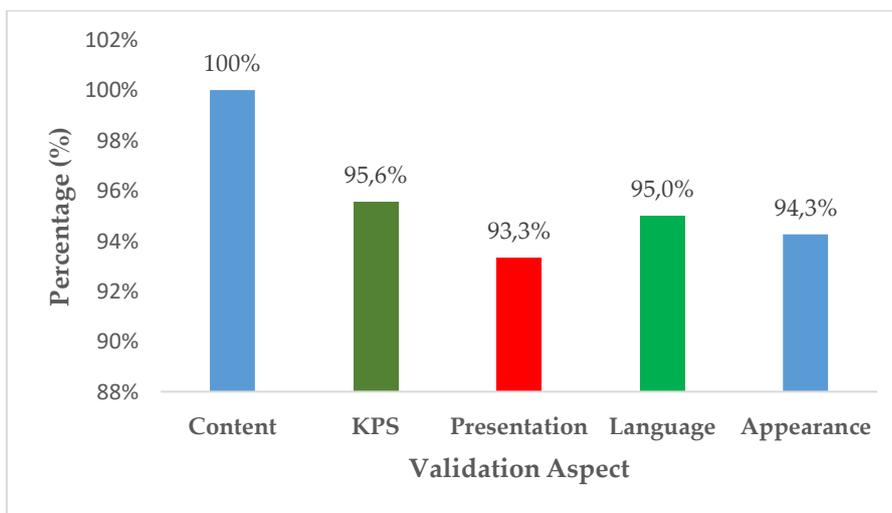


Figure 3. Validation Result by Teacher Judgement

The results of student responses that were tested on class XII IPA 5 students, totaling 10 students, were seen based on the results of the student response questionnaires which can be seen on Table 5.

Table 5. Results Aspects of Student Response Assessment

No	Aspects of validity assessment	Average	Percentage %	Validity level
1	Content Quality	4.6	92%	Very good
2	LKPD Display	4.23	84.67%	Very good
3	Language Quality	4.25	85.33%	Well
Average amount		4.03	87.33%	Very good

Table 5 shows the average results of student responses, namely 4.03 with a percentage of 87.33% in the very good category, which means that it is suitable for use in schools in physics learning activities. The percentage of the total aspect of the test results on the use of the product can be seen on Figure 4.

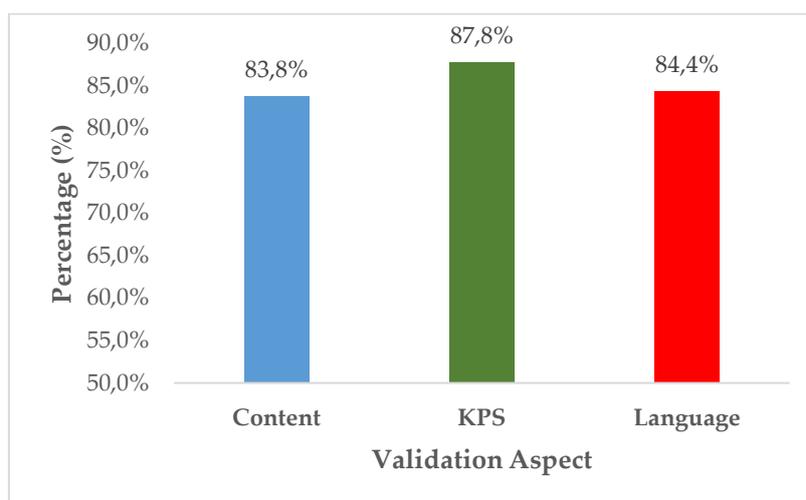


Figure 4. Percentage of Total Student Response

Based on the test of calculating the *N-Gain* score in the experimental class, it shows that the average value of the *N-Gain* score for the experimental class using STEM-based LKPD through Guided Inquiry on Thermodynamics material is 0.78 or in a percentage of 78% it with high category. While the test for calculating the *N-Gain* score in the control class shows that the average value of the *N-Gain* score for the experimental class using non-STEM-based LKPD through Guided Inquiry on Thermodynamics material is 0.62 or in a percentage of 62% with medium category. The results of the increase in *N-Gain* seen in the Thermodynamics material were obtained from the results of the pretest and posttest in each class, namely class XI IPA 5 as the experimental class and class XI IPA 3 as the control class. In the experimental class, the highest pretest score was 45 and the lowest score was 15, while in the control class the highest pretest score was 40 and the lowest score was 15. The pretest scores in the experimental class and control class has a different averages, for control class has a same average; higher score 28.75 while the average value of the pretest in the experimental class is 29.37.

Learning activities carried out using STEM-based LKPD through Guided Inquiry were developed to require students to carry out scientific activities through observation, making hypotheses, and conducting practicals as well as linking the concepts obtained with everyday life. Improving Science Process Skills in learning can be seen in the ability of students to propose hypotheses, apply concepts that have just been learned in new situations, can determine tools and materials, determine what is

observed, work steps, conduct experiments, and can determine how to process data from observations, tables, and diagrams, as well as compiling and submitting systematic and clear reports.

4. Conclusion

The development of STEM-based LKPD through Guided Inquiry that has been developed obtained the validation results of material experts by 2.36% and the percentage of media experts by 82.44%. The results of the feasibility test obtained a percentage of 95.43%, and the results of student responses in the use trial with a percentage of 87.33% so that it can be categorized as valid and feasible as a learning medium. The use of LKPD in the learning process as one of the stages of research and aims to see an increase in students' Students' Science Process Skills shows an *N-Gain* value of 0.78 with a percentage of 78% entering the high category. So it can be concluded that the STEM-based LKPD through Guided Inquiry produced is categorized as feasible as a learning medium and can be used in learning and can be used in physics learning to improve students' Students' Science Process Skills on thermodynamic material.

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