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Physics Learning Devices based on Guided Inquiry with Experiment to Improve Students' Creativity

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Abstract. In this study, we have developed physics learning devices based on guided inquiry with experiments to improve students' creativity. Research and development are carried out in several stages starting with preliminary studies to testing. Experts then validate learning tools that have been developed before being implemented to determine their effectiveness in increasing creativity. Validity data was obtained from the appraisal sheet for the appraisal of learning devices that are assessed by experts. The effectiveness data were obtained from the results of creativity tests in the form of tests of verbal, figural, numerical, and procedural creativity. The results of the study show that learning tools are valid and effective in enhancing student creativity. An aspect of procedural creativity was increased higher than other aspects.In addition, students can provide answers with original thoughts using their language based on experiments and the results of discussions that have been conducted.

Keywords: Learning device; Guided inquiry; Creativity.

1. Introduction

In the 21st-century technology is overgrowing. Creativity is needed to face the global competition. According to Munandar [1], large companies need people who have high creativity at work. However, this has not been fulfilled. Suhartini *et al.* [2] stated that a creative person could solve a problem from various points of view. Meanwhile, Kurniawan [3] stated that creative ideas could be used to produce a useful product. Educational institutions are required to be able to develop students' creativity. However, creativity is a form of thinking that currently lacks attention in formal education [4]. Ideally, every student has the creative potential [5]. This potential needs to be sharpened and given a stimulus so that it can develop well. Physics is one of the subjects that form creative students. Physics is one of the branches of science that studies matter, energy, and their relationship. An invention in the field of physics comes from observations and experiments which are part of the scientific process. Physics learning is a creative activity that requires new images and ideas from various points of view.

The results of a preliminary study in two different high schools in Mataram, Indonesia showed that the learning process was still teacher-centred. In general, teachers still teach conventionally by explaining concepts, then working on relevant questions.Students' interest in physics learning emerges when the material studied is directly related to its application. Students expect not only to be required to memorize material and solve mathematical problems but are given the opportunity to conduct experimental activities so that learning is more meaningful. According to Sugiana *et al.* [6], monotonous physics learning made physics learning difficult and boring. This limits the ability of students to develop their creativity. Because of that, the problems must be solved by the innovation learning model to improve student creativity.

One of the learning models that can support creativity is guided inquiry [7]. Guided inquiry learning models are designed to provide learning experiences for students through scientific methods [8]. In this model, students ask questions and conduct investigations to find answers. Students are actively involved in observing, asking questions, making hypotheses, seeking information, discussing, expressing opinions and objections, concluding, and presenting their findings. The process that occurs in this activity provides an opportunity to bring up unexpected new ideas. According to Anam [9], the inquiry learning model emphasises the activities of students who are active in learning. Activities in inquiry learning provide a learning experience that attracts students' attention, encourages students to make discoveries through various observations and experiments, helps students to express their various potentials, and maximises the memory of activities gained through direct experience. According to Kurniawan [3], the inquiry model that was usually used is a guided inquiry. This is because students are generally not used to learning by using inquiry methods and hence they need guidance in their implementation.

Suhartini *et al.* [2] showed that the development of guided inquiry-based learning tools could enhance students' creativity. While Mufiannoor [7] stated that a series of activities in the guided inquiry model could facilitate students to practice their creativity.Santofani *et al.* [4] stated that there was an increase in students' creativity after learning with guided inquiry models. Students can solve a problem with their ideas because they are required to be active in conducting experiments and analyzing data. Kurniawan [3] revealed that guided inquiry-based learning effectively improves creative thinking skills because students are actively involved in creating biology learning media.

Based on the description above, this study develops a physics-based learning device based on guided inquiry with experiment. It is expected that the learning device produced can improve students' creativity.

The rest of this paper is organized as follow: Section 2 describes the proposed research method. Section 3 presents the obtained results and following by discussion. Finally Section 4 concludes this work.

2. Research Method

Research and development are carried out onsome stages to produce products that are high in value. The research stages adapted from Borg & Gall's model include preliminary studies, planning, development of the initial product, design validation, design revision, initial trials, product revisions, and wider trials.

The validity data is obtained from the assessment sheet for the feasibility of learning devices by four experts. Validated aspects include content, presentation, and language. Expert advice is used to revise the learning device. The assessment results from experts are then analysed to determine the level of validity. ANATEST V4 is used to determine the validity and reliability of creativity test instruments. Furthermore, the trial was limited to 10 students to refine the product before being used in a wider trial.

Learning device was tested more broadly on two different schools to test the learning device toward students' creativity. School selection was based on considerations according to research objectives. The research subjects were 55 students who were learning the concepts of momentum and impulse. Student creativity data was obtained from the results of verbal, figural, numerical, and procedural creativity tests [10]. The results of the creativity test were also analysed descriptively to find out the uniqueness of the students' answers and related to the events during learning.

3. Results and Discussion

The initial product learning device developed in this study include the syllabus, lesson plans, student worksheets, and creativity test instruments. Experts validate the product. The assessment from the experts is then analysed to determine the level of validity. The results of the validation of the learning device are shown in Table 1.

Table 1. Validation results of learning devices

No	Aspect	Percentages of Average (%)	Validity Level
1.	Syllabus	85,19	very good
2.	Lesson Plan	84,76	very good
3.	Students' Worksheet	83,64	very good
4.	Creativity Test Instrument	84,24	very good
	Average	**84,46**	**very good**

Table 1 shows that the learning devices are categorized as very valid. There are some suggestions from the validator to revise the learning device. Each stage of guided inquiry in the syllabus and learning plan must be clarified so as not to appear like to be copying. In addition it is important to use sentences that can be applied directly in learning, reconsider the allocation of time at each meeting, simplify student worksheets to fit the time and material allocation, student worksheets are equipped with a summary of the material in the form of handouts, replace the images used in the creativity test figural with a simpler picture, simplifying the sentence of creativity test so students can immediately understand the purpose of the problem.

The research conducted by Chodijah *et al.* [11] about the development of physics learning devices using guided inquiry models showed that the learning tools developed are categorised as very valid when they have fulfilled the requirements for the preparation of learning devices. According to Rochmad [12], learning devices are said to be valid if they meet the criteria for content validity and construct validity. Content validity shows that the learning tools developed arebased on the curriculum. The construct validity shows consistency between the components of the learning device.

Limited trials were carried out on ten students related to student worksheets and developed handouts. Aspects assessed on student worksheets include clarity of action steps, clarity of language use, and display of student worksheets. Handouts include clarity of each sub-material, clarity of sample questions, language usage, and handout display. The results of limited trials are shown in Table 2.

Table 2. Limited trial results

No	Aspect	Score	Criteria
1.	Students' Worksheet	4,20	Good
2.	Handout	4,60	Very good
	Averege	**4,40**	
	Category		**Very good**

The suggestions obtained is to refine the product before being used in a wider trial. The suggestions are used to improve sentences in student worksheets and handouts to be more easily understood, improve the layout of images on student worksheets, simplify handouts on sub-collision perfect collision material, and complete sample questions on handouts with images of collision events.

3.1. Results of Student Creativity Test

Creativity test in the form of essay test consists of four types of tests, namely tests of verbal, figural, numerical, and procedural creativity. The creativity test indicator consists of fluency, flexibility, elaboration, and originality. The students' creativity test results are shown in Figure 1. The interval of creativity test is 1-100, with 1 as the minimum score and 100 as the maximum score.

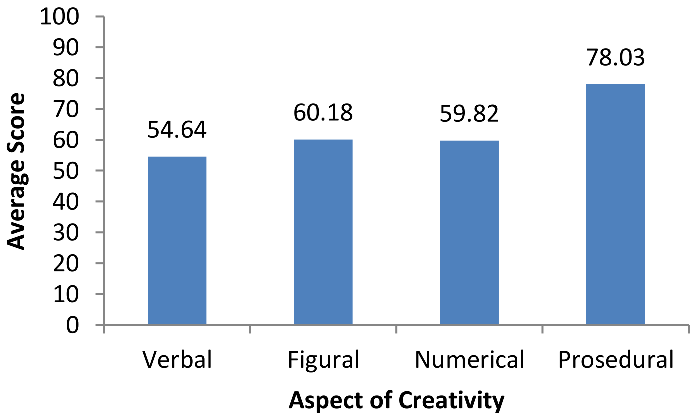

Figure 1. Results of Student Creativity Test

Figure 1 shows that the results of the procedural creativity test obtaining the highest score. Procedural creativity tests examine students' abilities in designing procedures for doing something [10]. The learning process uses a guided inquiry model with experiments can enhance students' procedural creativity. The procedural creativity of students is related to the steps of making simple rockets. The idea of how to make students can well design simple rockets contained in student worksheets. The guided inquiry model encourages students to be actively involved in learning [3]. Students are challenged to try something new. Problems formulated by students become the beginning of the investigation process. The proposed hypothesis is obtained by exploring initial knowledge and reading handouts. Direct experience gained when conducting water rocket launch experiments triggered group discussions. Students begin to discover that there is a reaction force to this event. The debate about what objects collide and what has to do with the law of conservation of momentum. Thisresult inaccordance with what Suhartini *et al*. [2] stated that when conducting experiment students feel euphoria during learning. This will lead students' new thoughts and ideas to solve a problem. In addition, the use of water rocket media can attract students' attention, so that they can link the concepts obtained to improve their creativity. According to Gunawan *et al*. [13], creative learning is carried out by providing media that can attract students' interests, material delivered close to real life, and creating a learning atmosphere where students are allowed to imagine freely. Increasing creativity is a positive influence of social media, so students have more open-minded.

When students are observing the shape of the water rocket at the time of the experiment, the new ideas emerged about how to make rockets. Students' curiosity is also seen in their enthusiasm asking the teacher. In addition, Sugiarto and Djukri [14] showed low results on related problems to rearrange a procedure because the procedures performed are rarely used in the daily lives of students. However, the procedure of modifying the tool gets a high score because students have previously been given direct experience through experiments.

Students' verbal creativity show the lowest results. The verbal creativity test examines students' abilities in explaining a case in the form of words [10]. According to Maliyah *et al*. [15], verbal ability in physics includes many terms. Some students succeed in providing as much explanation as possible about momentum and impulses. However, some students explain in general, for example, related to understanding, equations, and units. According to Magdalena *et al*. [16], students' verbal creativity did not affect learning achievement. This showed that in determining student, learning achievement is not only determined through verbal creativity but is much influenced by other internal and external factors.

Figural creativity tests examine students' ability to make possible pictures that occur in collision events. The results of the figural creativity test are higher than verbal creativity. According to Dewi *et al*. [17], the results of figural creativity tests were higher than verbal creativity. This shows students have a better ability to provide new ideas related to pictures. Learning with guided inquiry models provides opportunities for students to practice direct collision events through experiments. Students have been trained to analyse the possibility of images that occur in collision events. The students' observations are then expressed in the form of pictures on the student worksheet.

In contrast to these findings, Gunawan, *et al*. [18] revealed that verbal creativity increased higher than figural creativity through experiments on virtual experiment activities. Students can associate their ideas well through verbal communication. Sugiana, *et al*. [6] showed that the figural creativity of students in the experimental group was less developed because the use of computer-based laboratory media limited the students' ability to complete the picture. In addition, Gunawan, *et al*. [19] reported that the low figural creativity is because students are not yet accustomed to solving physical problems related to images. These findings indicate the magnitude of the influence of habituation and drawing exercises to improve students' figural creativity.

Numerical creativity is related to students' ability to find new equations. Test results show that students are capable of giving answers. According to Gunawan [10], numerical creativity is related to mathematical numbers and equations. Learning using guided inquiry models helps students to construct their understanding of mathematical equations in student worksheets. Students were able to reduce mathematical equations and raise interesting questions during the discussion. This showed the creativity of students began to develop. Purwasih [20] stated that students' mathematical understanding couldbe improved through learning guided inquiry models. Students who have an excellent mathematical understanding not only memorise formulas but can solve problems that require the ability to associate various kinds of concepts.

Besides being viewed from the aspect of creativity, the analysis is also carried out related to creativity indicators including fluency, flexibility, elaboration, and originality. The results of the student creativity test on each indicator are shown in Figure 2.

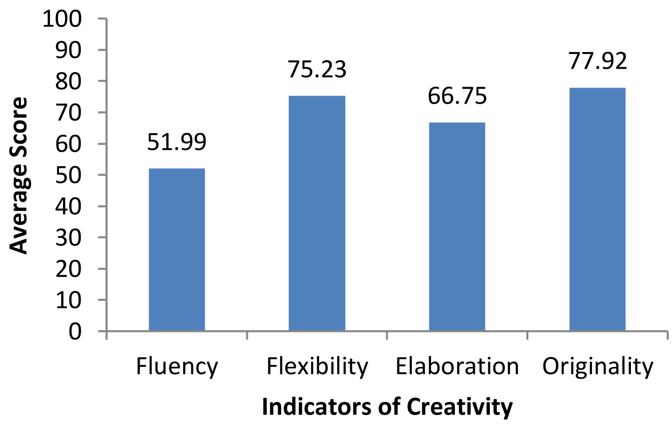

Figure 2. Results of Student Creativity Test on Each Indicator

Figure 2 shows the results of the highest creativity test found in the originality indicator. This is because the idea of how to make a simple rocket can be designed using original thinking from observing the shape of a rocket. An interesting finding from the results of the creativity test is that students explain the material that has been studied using their language based on experiments and the results of the discussions that have been conducted. Hasbi [21] stated that guided inquiry-with experiments play the proper role of scientists to find their concepts. His experience was then stored in long-term memory and can be remembered longer. Students can pour their ideas and ideas with the understanding they get. According to Silaban [22], there was a positive relationship between conceptual understanding and creativity. This means that students will be creative when they have understood the concept of physics well. In addition, Wibowo and Laksono [23] stated that the creativity of students increased after being given learning using a guided inquiry model. This is because previously learning focused on the lecture method so that the creativity of students was less developed.

Flexibility indicators have increased. In learning activities, students were trained to find information independently, then given guidance so that they can produce different answers to a problem. According to Munandar [1], flexibility is the ability of students to provide various ideas by looking at problems from different perspectives. Syafii *et al.* [24] stated that flexibility shows the ability of students to provide some interpretation of an event. According to Gunawan, *et al.* [25], creative students were able to create ideas that are different from their friends. After being taught using a guided inquiry model students who understand the material more deeply tend to be able to provide answers from different points of view. According to Gunawan, *et al.* [26], problem-solving in physics learning has a different solution for the same case. Ongoing training can enhance problem-solving skills.

The elaboration indicator was higher than fluency. Thisis because students were directly involved in learning. The material learned can be explained more during the discussion. Students were able to elaborate on a problem to become more detailed because of the knowledge from experiment activity. Gunawan, *et al.* [25] reported that the elaboration indicator shows students' creativity to describe a problem in detail. After students were able to create new ideas, students can explain their findings in more detail in group discussions.

The fluency indicator shows the lowest results. During the learning process using guided inquiry models presented a phenomenon related to momentum and impulses in daily life. The activities presented on student worksheets require students to be able to formulate problems and make hypotheses to be further proven through experiments. When analysing the data, students guided by the questions in the student worksheet. In the discussion process, students must also find information from the hand out to answer the questions on the student worksheet. The possibility of a low development of fluency indicators because of the information obtained by students from reading students can not remember handouts. The answers given are limited to concepts that can be remembered. Mufiannoor, *et al.* [7] stated that the more answers were given, the more creative someone is. According to Gunawan [25], the most important thing about the fluency indicator is students can give as many new ideas as possible, even though the idea is beyond the solution of the problem. Thus the indicator of fluency will increase if students can provide as many relevant answers as possible.

4. Conclusion

Based on the results of research and discussion, it can be concluded that the tools of guided inquiry-based learning that have been developed are in a very valid category. The results of the trial show that the learning devices effective to enhance students' creativity, especially in procedural aspects. The increase is related to the indicator of originality. Students were able to provide answers based on original thinking from observing the shape of the rocket. Students can explain the material that has been learned using their language based on experiments and the results of the discussions. Guided inquiry model with an experiment in learning physics can help students become more creative, especially in aspects of procedural and figural creativity. In the indicator of creativity, a high result was obtained on the indicator of originality, and the lowest is on the indicator of fluency. The suggestion of this study is the development of learning devices based on guided inquiry with experiments should be arranged at the time allocation as well as possible so that each step can take place maximally.

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