Physics experiment activities to stimulate interest in learning physics and reasoning in high school students

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Abstract. Physics experiments are accompanied by questions that challenge students in learning the topic of the center of gravity which is intended as an alternative solution to foster student interest and reasoning. This research method is classroom action research. Learning is carried out in two cycles in two different identical classes each consisting of 36 students. The improvement in cycle-2 is based on the reflection of learning cycle-1, namely the revision of the use of terms in the student worksheet and the guidelines for carrying out experimental activities to be simpler and more efficient. The implementation in cycle 2 shows that there is no more input from students regarding the unclear work to be done. The results showed that students enjoyed learning (89% cycle-1; 94% cycle-2) and felt more understanding (78% cycle-1; 86% cycle-2), expressing the inspiration they obtained (56% cycle-1; 64% cycle-2). Students stated that they preferred to study the mechanism of physics rather than solving the problem using a formula (58% cycle-1; 94% cycle-2) because they thought it was more useful. The distribution of students' reasoning scores is better than the ability to solve problems, especially students get a lot of difficulties at the problem identification stage.

1. Introduction

One of the problems of learning physics in high school which is a challenge for teachers is the low interest in learning and how to make students use reasoning in solving problems [1-3]. Physics learning in general is still based on formulas and training procedures to solve problems. Thus, learning does not emphasize students' thinking and reasoning but tends to memorize formulas and steps to solve problems. The lack of students' ability to extract the main principles or concepts in the context of the problem causes students to tend towards a more formulaic approach to problem solving [4]. The effort to develop reasoning in solving physical problems in this research is to carry out experimental activities with challenging questions. Scientific reasoning can be developed through inquiry, experimental activities, evaluation of evidence and inference [5].

The difficulty of students in solving problems causes students increasingly not interested in learning physics. Negative attitudes in student learning will further aggravate student learning outcomes. Learning must create pleasure first so students are interested in learning [4]. Students must have a successful learning experience so they can have an interest in learning physics. Active learning experiences can change attitudes to improve student interest in learning [6-7]. So, the experimental activity is a way to create fun in the classroom, then it can be dragged through challenging questions on worksheets to further encourage students to use reasoning in solving physics problems.
2. Methods

Respondents in this study consisted of two class high school science students, namely: 36 students (XI IPA3) and 36 students (XI IPA1). The two classes are identical with the homogeneity test using SPSS with a significance value \( p = 0.855 > 0.05 \). The research method used was classroom action research. Learning takes place in cycle 1 (XI IPA3) and cycle 2 (XI IPA1) on the topic of center of gravity. Observations in cycle 1 are made to improve learning implementation in cycle 2.

In the implementation of learning, there were 7 out of 36 students stating difficulties in understanding the worksheet and the teacher's explanation guiding the experiment in cycle 1, then making improvements in cycle 2 by changing some terms in the worksheet and providing scaffolding to help students understand concepts and experiments. Questions and explanations that were originally open ended are assisted with prompting questions.

Data were collected through observation, questionnaires, interviews, and written tests. The suitability of learning and plan is observed through the observation sheet. Student responses to learning were explored through questionnaires and confirmed through interviews. Open ended written test is analyzed to find out the pattern of students' problem solving. Learning is carried out by team teaching (as a teacher, as an observer, as a documentation officer). Data were analyzed using qualitative descriptive.

3. Results and Discussions

Aspects to be explored in this study include: students' responses to the implementation of learning, the development of student reasoning and patterns of analysis of students in solving physical problems.

3.1. Student responses to the implementation of learning

The implementation of learning about the center of gravity based on experimental activities accompanied by challenging questions on the worksheet received positive responses. Student responses are presented in Figure 1.

![Figure 1](image)

**Figure 1.** The answer to the question "Is learning physics fun for you?"

Figure 1 shows that most students (more than 85%) are happy with experiment-based learning. Students state the reasons such as: not boring, relaxed, can observe reality, can clarify concepts, prove theories, gain knowledge about how to do research. According to students, learning physics must always be supported by experiments. Learning by experiment allows knowledge acquisition and understanding of science concepts to be better, develops science process skills, attitudes and motivation to learn more positively, and can enhance the role of social interaction as a catalyst for learning [8-9]. Learning activities can at least be oriented to minimize the perception of Physics that is difficult that is rooted in society [10].

Student responses to questions as far as learning has inspired you, the following students' answers are presented in Figure 2.
In accordance with Figure 2, some students claimed to be inspired by experiment based learning. The students’ reasons stated were as follows: (1) I aspire to become an architect so that I must be able to determine the center of gravity of a building to get a stable building; (2) If the center of gravity of the rocket can be determined, maybe I will be able to control the movement of the rocket; (3) I want to know the center of gravity of animals such as cows, ducks, etc.; (4) I want to try to determine the center of gravity of the objects around us, maybe there is something I can do. Students’ impressions of learning that make them feel happy are related to the fact that learning has provided something useful for them.

3.2. Response about student understanding in learning

According to the questionnaire and confirmed through interviews obtained recognition that they feel more understanding about the concept and its application in determining the center of gravity of an object in everyday life, as presented in Figure 3.

Figure 3 states that most students claim to understand more, but some feel that they are not sure they can work on problems that require mathematical calculations. This doubt is most likely due to the habit in students’ minds that solving physics problems always requires mathematical formulas that make it difficult for them. These students’ statements relate to the data presented in Figure 4.
Figure 4 shows a shift in the perspective of students learning physics from the formula approach towards examining how the mechanism of physics works. The habit of learning physics using common sense and mechanistic reasoning is more productive than memorizing formulas [11].

Challenging questions in experimental activities are very important to direct student reasoning. For example, after students complete an experiment about determining the center of gravity, they are then given a question about how to determine the center of gravity on homogeneous objects. Students will be triggered to find new ideas based on real experiences that have just been done. Another example of the question is whether the center of gravity of an object always coincides with the center of mass of that object. The role of guide questions encourages students to think in experiments. Guides in experiments help students conduct experiments mainly in exploring prior knowledge and scientific skills needed in completing scientific inquiry tasks [12-13]. This statement about how students learn is related to essay test scores in solving physical problems, as presented in Figure 5.

In Figure 5 it is shown that students' scores in solving problems that require reasoning answers are better than problems that require mathematical answers. This data corresponds to the previous student learning outcomes which on average have low mathematical abilities. The difficulty of students in
solving physics problems using mathematics is caused by their minimal mathematical ability. Even though mathematics is the language of physics. Difficulties of students in solving physics problems are mostly related to the application of mathematics to the appropriate physics problem [14]. Lack of mathematical ability that causes students to prefer problem solving through reasoning rather than problems that use mathematics. However, studying physics through reasoning is still better than using the formula approach [11]. In fact, learning mathematics using a problem-solving approach is better than without problem solving [15].

3.3. Pattern analysis of students solving physics problems

Student skills in problem solving are analyzed based on stages: identifying problem, planning, and executing the solution, as presented in Figure 6.

![Figure 6. Patterns of solving students' physics problems](image)

In Figure 6 it is shown that students' difficulties in solving physics problems are initiated by weaknesses in identifying problems. Student skills in problem identification on average are lower than skills in planning. The reasoning habits that have been developed during learning have not been able to foster the ability of students to extract the main issues in the physics problems presented. Students can directly answer physics problems qualitatively by relying on their reasoning. However, students are confused when confronted with physics problems involving interrelated variables. The process of identifying physics problems includes the steps of recognizing, mapping, and describing problems systematically. Skills in identifying physics problems also depend on mastering various forms of problem representation [16]. Regarding this issue requires specific treatment. Physics problem solving skills are influenced by various factors, including internal and external factors. The lack of problem solving exercises in various contexts related to the concepts and principles of physics being a factor in the ability to solve physics problems is low [17].

4. Conclusion

Based on the results of this study, it can be concluded that physics experiment activities accompanied by challenging questions can improve students' interest in learning and develop reasoning. Shifting students' habits in solving physics problems from the formula approach to the use of common sense and reasoning will encourage students to think more productively. Students' skills in identifying problems are still lower than planning and executing solutions.

Acknowledgement

The author would like to thank the Ministry of Research, Technology and Higher Education, especially to the Director General of Human Resources Development through the School Lecturer Assignment Program (PDS) for funding this research. Thanks also to UNNES for organizing the grant.
References

[1] Wartono, Suyudi A and Batlolona J R 2017 EduLearn 12 319
[2] Batlolona J R, Bascar C and Kurnaz M A 2018 JPII 7 273
[3] Astalini, Kurniawan D A, Perdana R and Kurniasari D 2018 The Educ. Rev. 2 475
[4] Docktor J L, Mestre J P and Ross B H 2012 Phys. Rev. Phys. Educ. Res. 8 020102
[5] Marusic M and Slisko J 2012 Int. J. Sci. Educ. 34 301
[6] Smith E M, Stein M M, Walsh C and Holmes N G 2020 Phys. Rev. X 10 011029
[7] Berland L K, Schwarz C V, Kenyon L, Lo A S and Reiser B J 2016 J. Res. Sci. Teach. 53 1082
[8] Snetinova M and Kacovsky P 2019 J. Phys.: Conf. Ser 1287 012049
[9] Williams S R G, Ziebell A L, Thompson C D and Overton T L 2020 Int. J. Sci. Educ.42 451
[10] Oon P T and Subramaniam R 2011 Int. J. Sci. Educ. 33 727
[11] Krist C, Schwarz C V and Reiser B J 2018 J. Learn. Sci. 28 1
[12] Van Riesen S A N, Gijlers H, Anjewierden A and De Jong T 2018 Int. J. Sci. Educ.40 1327
[13] Ural E 2016 J. Educ. Train. Stud. 4 217
[14] Pospiech G, Eylon B, Bagno E and Lehavi Y 2015 Il Nuovo Cimento 38C 1
[15] Khatimah H and Sugiman S 2019 J. Phys.: Conf. Ser 1157 042104
[16] Bollen L, Kampen P, Baily C, Kelly M and De Cock M 2017 Phys. Rev. Phys.Educ. Res 13 020109
[17] Jua S K, Sarwanto, and Sukarmin 2018 J. Phys.: Conf. Ser 1022 012027