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Fostering Habits of Mind Through Giving Real-World Problems in Physics Learning

Mujib Ubaidillah[1,2 a)] Putut Marwoto[3, b)] Wiyanto[3, c)] Bambang Subali[3, d)]

Author Affiliations
[1] *Doctoral Programme of Science Education, Faculty of Mathematics and Natural Science, Universitas Negeri Semarang, Semarang, Indonesia.*
[2] *Biology Education, Faculty of Education and Teacher Training, UIN Siber Syekh Nurjati Cirebon, West Java, Indonesia.*
[3] *Department of Physics Education, Faculty of Mathematics and Natural Science, Universitas Negeri Semarang, Semarang, Indonesia*

Author Emails
[a)] Corresponding author: [a)]*mujibubaidillah@students.unnes.ac.id*
[b)]*pmarwoto@mail.unnes.ac.id*
[c)]*wiyanto@mail.unnes.ac.id;*
bambangfisika@mail.unnes.ac.id

Abstract. Habits of habits need to be trained to students in physics learning. Students are often faced with situations that require problem-solving solutions. This study aims to train the habits of mind through a problem-solving laboratory based on real-world problems. The research method uses a one-shot case study experimental design. The study's subject were 25 Biology Education students taking introductory physics courses. The instrument used was a questionnaire with a Likert scale that met the elements of validity and reliability. Students' habits of mind were measured in series each time the practicum was completed within one semester. Statistical test to see the development of habits of mind in repeated experiments using Repeated Measures ANOVA. The study results showed that giving real-world physics problems can foster students' habits of mind. Real-world problem-solving activities through brainstorming and proof activities through physics experiments have impacted students' habits of mind. The research results can be used as recommendations in designing physics learning that trains habits of mind.

INTRODUCTION

Habits of mind are the abilities needed by individuals to solve problems in everyday life (1). Previous research shows that habits of mind contribute significantly to student success in learning (2). In physics learning, scientific activities need to be supported by habits of mind that are consistently trained (3,4). Habits of mind can be seen as one of the important competency achievements in the learning process (5). Therefore, training habits of mind in physics learning is a must (6).

Students' habits of mind in basic physics practicums are still low in terms of habituation in producing ideas to solve physics problems, habituation in creative thinking, and students' perspectives on physics problems need to be improved (7). The problem of low student habits of mind needs to be solved. If this is left alone, the objectives of basic physics learning will not be as expected.

The goal of learning physics is not only limited to mastering theoretical concepts, but also includes the development of critical, creative, and analytical thinking skills which are part of the habits of mind. Effective physics learning must be able to train students to continuously ask questions, solve problems, and think reflectively in dealing with natural phenomena. Students not only understand the laws of physics, but are also able to apply them in real-life contexts. Integration of habits of mind in physics learning can improve students' scientific thinking and problem-solving skills, which are the main goals of physics education (6). This is in line with Murray's view which emphasizes the importance of physics learning that actively involves students in the process of thinking and experimentation, in order to foster strong habits of mind (4).

Physics labs that are effective in training habits of mind have several main characteristics. First, the lab should be investigative and exploratory, where students are encouraged to formulate questions, propose hypotheses, and design and carry out experiments independently (4). Second, the lab should emphasize critical reflection, which allows students to think about their own thinking processes (metacognition) and evaluate experimental results carefully (8). Third, physics labs need to provide opportunities for students to work collaboratively, hone interdependent thinking skills, and learn from the perspectives of others (6). In addition, lab activities should be designed to challenge students in solving complex problems and applying physics knowledge in new situations, so that they can develop flexible and innovative thinking habits (5). The habit of solving real-world problems can improve students' habits of mind (9). This is in accordance with the results of research stating that problem solving is a mediator in developing students' habits of mind (10). Physics labs not only deepen students' conceptual understanding, but also strengthen habits of mind that are essential for success in learning and everyday life.

Habits of mind research has been conducted by previous researchers in various fields such as mathematics (11–16), spatial habits of mind in GIS learning (17), and socio-scientific issue-based chemistry learning (18–20). However, learning that trains habits of mind in physics learning through experiments has not been conducted by previous studies. This study aims to reveal students' habits of mind that are trained through solving physics laboratory problems. Research on habits of mind in physics learning shows an increase in attention to the importance of developing critical and analytical thinking skills as part of student competence. Various previous studies have examined habits of mind in the context of mathematics, chemistry, GIS, and social science education, but studies that specifically integrate habits of mind in physics learning are still limited. Most studies focus on theoretical approaches without paying sufficient attention to how habits of mind can be trained through physics laboratory experiments. The novelty of this study lies in the effort to fill this gap by developing a physics learning model that directly involves students in laboratory activities, with the aim of training and measuring the development of their habits of mind in the context of solving scientific problems. This approach is expected to provide new contributions to the development of physics pedagogy and broaden the understanding of how habits of mind can be strengthened through practice-based learning.

METHODS

This study used a one-shot case study design, which aims to evaluate the effects of laboratory-based physics learning on students' habits of mind. The sample of this study consisted of 25 students majoring in Biology Education who were selected purposively from a population of 81 students. This design was chosen to observe the results of a single learning intervention without a control group, so that the results can provide an initial picture of the effect of laboratory work on students' habits of mind. The intervention was carried out 5 times. Each intervention, students were given experiments with 5 different topics. Experimental topics in the intervention included springs, fluids, heat, electrical circuits, and optical devices. Students were divided into 5-6 groups. Each group consisted of 4-5 students. The instrument used in this study was the habits of mind questionnaire, developed by Costa and Kallick and Etkina. This questionnaire covers various dimensions of habits of mind that are relevant to the context of physics learning, such as critical thinking, creative thinking, and reflective thinking. The questionnaire uses a Likert scale of 1-4.

The instrument developed by Costa and Kallick includes 16 indicators, persisting; listening with understanding and empathy; thinking about your thinking (metacognition); questioning and posing problems; thinking and communicating with clarity and precision; creating, imagining, and innovating; taking responsible risks; thinking interdependently; managing impulsivity; thinking flexibly; striving for accuracy; applying past knowledge to new situations; gathering data through all senses; responding with wonderment and awe; finding humor; and remaining open to continuous learning (8,21). The questionnaire instrument also adapts from Etkina's Habits of Mind in Physics, namely drawing a sketch before solving a physics problem, applying normative statements to experimental testing, evaluating assumptions, and treating each experimental result as an interval (22).

Data obtained from periodic measurements of habits of mind during several practicums were analyzed using an inferential statistical approach to understand the development and changes in students' habits of mind along with the

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implementation of physics practicums. To test for significant differences in students' habits of mind throughout the practicum series, Repeated Measures ANOVA (Analysis of Variance) was used. The Repeated Measures ANOVA method is suitable because the data is measured from the same subject at several points in time, making it possible to identify whether there are significant changes in habits of mind as the practicum progresses. Before conducting the analysis, the assumptions of Repeated Measures ANOVA such as data normality and sphericity will be tested using the Shapiro-Wilk test and Mauchly's Test of Sphericity.

RESULTS AND DISCUSSION

Students' habits of mind are trained in problem solving that is solved through experimental activities. The provision of real-world problems (problem statements) at the beginning of learning is used as a stimulus for students' habits of mind. Physics experimental activities are carried out in 5 meetings. Each meeting contains practicums with different topics. Students are given worksheets to discuss with friends in one group. Students brainstorm to discuss problem solving. Students express ideas for solving problems. Furthermore, students choose the best idea as a way to solve problems through experiments. Students answer questions to strengthen conceptual knowledge, make predictions, conduct exploration, determine equipment, analyze research results, and conclude. Real-world problems in physics learning based on problem solving laboratories can be seen in Figure 1.

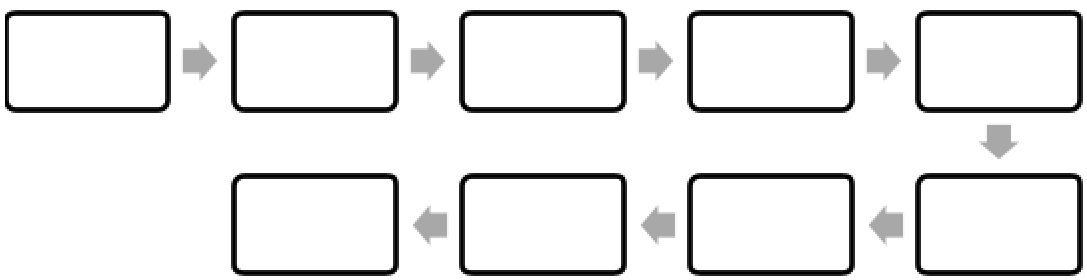

FIGURE 1. Problem-solving laboratory model with real-world problem

Students' habits of mind were measured every time they conducted an experiment. The results of the habits of mind questionnaire were subjected to statistical tests to see the difference in the increase in habits of mind as a result of the intervention in the form of a physics experiment. The results of data normality using Shapiro-Wilk are shown in Table 1

TABLE 1. Test of normality Shapiro-Wilk.

Standardized Residual	Statistic	df	Sig.
Experiment 1	0.957	25	0.361
Experiment 2	0.956	25	0.343
Experiment 3	0.967	25	0.580
Experiment 4	0.960	25	0.480
Experiment 5	0.968	25	0.601

The standardized residuals of the five practical interventions have a significance value of more than 0.05. The significance result of more than 0.05 means that the data is normally distributed as shown in Table 1. The significance value of Greenhause-Geisser shows that the data has a homogeneous variance. The significance value of Greenhause-Geisser is greater than 0.05 as shown in Table 2

TABLE 2. Mauchly's test of Sphericity.

Within Subject Effect	Mauchly’s W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser
Experiment	0.064	61.624	9	0.000	0.481

There is a significant difference in students' habits of mind after the intervention. The significance value of Sphericity Assumed is greater than 0.05 as shown in Table 3, this shows that the intervention of providing real-world problems in basic physics practicums can improve students' habits of mind. The significance value of Greenhouse-Geisser is less than 0.05, this shows that there is a real difference in the increase in habits of mind due to the experimental intervention.

TABLE 3. Test of within-subjects effects.

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Experiment	Sphericity Asumed	23768.688	4	5942.172	31.300	0.00
	Greenhouse-Geisser	23768.688	1.922	12365.365	31.300	0.00

The results of the multivariate test in Table 4 show that there is a significant difference between the experimental conditions on students' habits of mind, which means that various experimental activities carried out in physics practicums have a real and significant impact on the development of students' habits of mind. The significance value of Pillai's Trace is less than 0.05 indicating that the variation between experimental groups makes a major contribution to changes in students' habits of mind.

TABLE 4. Multivariate test.

Effect		Type III Sum of Squares	F	Hyphotesis df	Sig.
Experiment series	Pillai's Trace	0.786	19.290	4.00	0.00
	Wilks' Lambda	0.214	19.290	4.00	0.00
	Hotelling's Trace	3.674	19.290	4.00	0.00
	Roys'Largest Root	3.674	19.290	4.00	0.00

Repeated practicums can play a significant role in improving students' habits of mind. Habits of mind are intellectual attitudes that influence how individuals face and solve problems (21). Research shows that habits of mind are related to behaviors that allow individuals to solve problems efficiently and effectively, often automatically without requiring deep memory (23). Through practice and habituation, students can internalize deep thinking habits so that they can apply skills in various real-life situations. Practical activities that repeatedly involve students in solving real-world problems can strengthen their habits of mind (9,10). Problem-oriented learning and involving practice can improve habits of mind (16,24). By facing and solving various problems presented in physics practicums, students not only develop a deeper understanding of concepts, but also hone their critical, creative, and structured thinking skills, all of which are part of habits of mind (3). Previous research also confirms that mastery of physics concepts is very important in improving habits of mind; the better the mastery of concepts, the better the habits of mind that are formed (25). Thus, learning involving repeated practicums provides essential opportunities for students to strengthen critical, creative, and structured thinking habits through continuous practice and real-world applications in complex situations.

CONCLUSION

Real-world problems in physics experiments have a real impact on the development of students' habits of mind. Physics experiments that are carried out repeatedly contribute to improving students' habits of mind. Recommendations for further research are to explore more deeply how variations in the types of real-world problems used in physics experiments affect various aspects of students' habits of mind, such as critical thinking, creativity, and decision making. In addition, research also needs to focus on the optimal duration and frequency of repeated practicums to achieve maximum improvement in habits of mind. Further research to assess the effectiveness of implementing other learning models that may support improving habits of mind outside of physics practicums.

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