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Analysis of Attitudes and Approaches to Problem Solving: Gender Differences and Education Levels

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Abstract

The main problem in this research is the low ability of students to solve physics problems. Students' attitudes and approaches to problem-solving are allegedly related to the way they study physics and their success in solving physics problems. This study demonstrated student attitudes and approaches to solving physics problems using Attitudes and Approaches to Problem Solving (AAPS) survey questions using quantitative methods. Data were collected from 1045 students. Data analysis was carried out by grouping the data by gender and education level. The t-test was used to see the differences in each group. The result showed no statistically significant differences between men and women (t = -1,65 dan Sig. = 0,098 > 0,05). In addition, there was a significant difference in the level of education between collect students with junior and senior high school education levels (p < 0.05). The implications for practice, and the directions for future research are discussed.

Keyword: *Attitude, Gender, Problem solving*

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1. Introduction

One of the objectives of learning physics is to improve their problem-solving skills so that they able to transfer their knowledge and skills into the practices [1]. These skills are important to enable students to use their knowledge to analyze new situations by applying problem-solving skills [2]. Students' attitudes and approaches to learning physics can have an impact on their learning outcomes [3], [4]. To master the concepts of physics, students need to acquire a strong knowledge structure and attitude towards learning physics. Throughout the stages, one becomes an expert in solving physics problems through stages by cultivating an attitude towards knowledge and learning in physics.

Students' ability to solve physics problems is still relatively low. Students prefer to directly use mathematical equations by guessing the formula [5]. Students are more likely to use a trial-and-error approach in solving physics problems [6]. Difficulties experienced by students when faced with complex problems that first require analysis [7]. This is not following the goal of learning physics to create human beings who can solve problems by applying their knowledge and understanding to everyday situations.

Many students think that physics is a collection of facts and formulas by ignoring the necessary knowledge structures. Students believe that only a few of them can do physics problems, the teacher is the main authority who teaches physics. Students assume that the tasks in physics are taking notes, memorizing, taking exams and then forgetting them [8]. As a result, students do not try to integrate and analyze what they have learned. Students are less likely to ask questions, connect concepts, and extend their knowledge beyond what is being taught. If the student cannot solve the problem within 10 minutes, the student will give up immediately and will not try to find a challenging problem-solving strategy [9].

Studies showed that students tend to be less attentive after attending a lecture [4], and learning cannot change a student's beliefs after learning physics [10], [11]. The tools of attitudes and approaches for students to solve physics problems are Colorado's attitudes towards scientific research (CLASS) [3], [12], attitudes up to problem-solving research (APSS) [10], [13], Attitude and Approach to Problem Solving (AAPS)) [9], [14]. The effectiveness and reliability of AAPS equipment was calculated using the Cronbach alpha (α) measurement scale [9]. In addition, the AAPS instrument was developed by adding several items and investigating the factor structure using exploratory factor analysis (EFA) to find nine factors [15].

Becoming an expert in solving problems requires an effective understanding of physics by combining different ideas and concepts [16]. When learning physics, beginners are expected to be able to effectively develop the structure of the knowledge so that they can remember information when needed [17]. The results of observations using traditional methods in solving physics problems do not fully support students' conceptual understanding well [18]. On the other hand, when it comes to connecting physical concepts, the student's conceptual framework is very low and, this can cause difficulties in solving problems [2].

The heuristic problem-solving step according to [19] contains four steps, namely: 1) Understand the problem (understand the problem). 2) Plan a settlement (make a plan). 3) Problem solving according to the plan (execution of the plan). 4) Please check again. The use of problem-solving strategies by students will be different if they are faced with the same problem but the context is different [20]. Problem-solving strategies used by students differ for problems in different situations [21], and strategies differ between professionals and beginners [22], [23]. Thinking habits need to be developed in order to build knowledge in a structured way and guide students to develop cognitive processes [24].

The cognitive structure that influences the solution of physical problems is metacognition [25]–[27]. Students need to pay attention to how and when students use their knowledge [17] such as using pictures in solving problems [28]. The methods used by students in solving problems need to be explored in order to have an impact on their learning outcomes. Although many problems have been solved, this is not correlated with students' conceptual understanding [29]. On the other hand, the structured solution of the problem affects the student's understanding [30].

Problem-solving is not only limited to have good structure, but needs to be extended to real life problem-solving. Problem-solving has obvious limitations on the level of education of students, so it is necessary to provide support to help them develop problem-solving skills. Problem solving ability must be seen at each stage of education level, as a result, ability development process can be developed in parallel [31]. Although there is no significant difference between majors and between male and female students towards students' attitudes and approaches in solving physics problems, high performance people have better attitudes and approaches in solving problems than others [32]. Several studies have been conducted to examine the effect of problem-solving gender on problem solving [14], [33], [34].

Previous research found differences in abilities by genders such as visual-spatial ability [35], ability to solve physics problems [36], and several tests of understanding physics concepts [37], [38]. Seeing the biological differences between men and women that will affect changes in knowledge, attitudes and behavior. Therefore, the assumption used in this study is that gender differences may occur in their attitudes and approaches to solving physics problems.

However, there is no clear evidence that the education level is better for solving problems than others. This is very important to know as a follow-up to improve their attitude and approach to problem-solving. This study uses the AAPS survey question [9] to determine the effect of education level and gender towards attitudes and problem-solving approaches in physics. Our results will contribute to the development of physics education and help fill this research gap.

2. Method

Quantitative research methods with survey research are used to describe the attitude and approach data of students to solve physics problems. This research was conducted to evaluate the attitudes and approaches of students to solve physics problems. Previously, adaptation of the AAPS survey question was carried out which refers to processes developed in other languages [35]. The first phase was adapted the instrument which originally written in English and translated into Indonesian. The second phase was group discussion forum with teachers and lecturers to evaluate the AAPS instruments that have been translated and then used for data collection.

2.1. Sample

The study groups were selected according to the level of education, namely Junior High School, Senior High School and College Students. Sampling was based on grade level for junior high school (JHS) (grades 7, 8, and 9), senior high school (SHS) (grades 10,11 and 12) and college students (class of 2021, 2020 and 2019). Research data collection was carried out in direct coordination by subject teachers at every level of education and at the student level coordinated by researchers. Voluntary participation as a basis for ensuring that students give honest answers. A total of 1046 volunteers participated in this study with details of JHS (N = 693), SHS (182) and College Students (N = 171). The group of men who filled out the instrument was 39% (N = 413) and 61% women (N=633).

2.2. Instrument

The phrase in the article that there was no potential conflict of interest was reported by the authors as our basis for using AAPS [36]. AAPS translated into Indonesian was verified by three physics education lecturers. The instrument was revised based on suggestions from lecturers regarding a suitable translation from English to Indonesian. Next, we asked for suggestions and responses from teachers (N= 20) and physics education lecturers (N= 5) to conduct an evaluation. Based on the suggestion, two statements were added, namely (1) Before solving physics problems, I first understood the concepts and principles of the problem, and (2) Studying sample questions helped me more in solving physics problems than understanding the concepts and principles of physics first. The results of the revised AAPS (Indonesian version) were applied to more than 1046 students (junior high school, high school and university students). Before conducting the analysis, we calculated the reliability of the instrument using the Quest software. The calculation results obtained reliability of estimate .94 and there were no items outside the rejection area (Figure 1). Based on this, the analysis continued to see the differences in attitudes and approaches of students in solving physics problems.

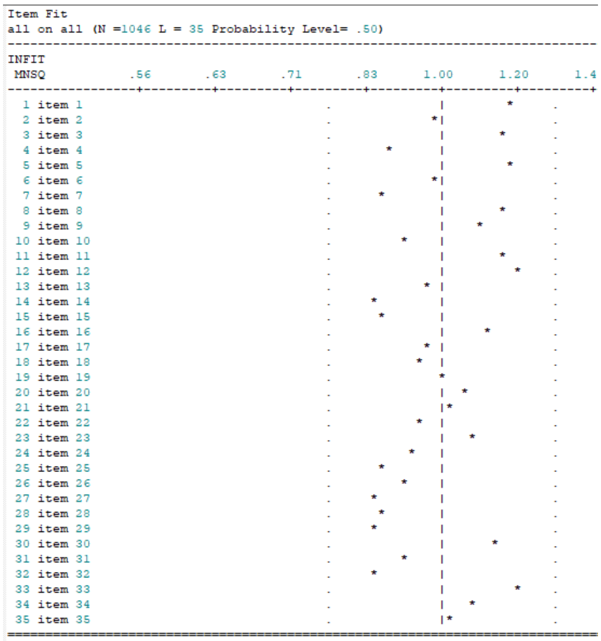

Figure 1. Item receiving area

The analysis was performed using SPSS version 23 software. Each item was calculated with descriptive statistics (mean and standard deviation). To determine the significant difference between men and women and the level of education, a t-test was performed [37] with the assumption that normality was met. The assumption of homogeneity of variance was tested using Levene's test [37]. The significance assumption used is 0.05. Pearson correlation [38] was carried out on the total AAPS score to explore the extent of differences in each group of students.

3. Result and Discussion

The results presented in the discussion are based on the research objectives: (1) measuring students' attitudes and approaches to problem solving; (2) investigate the extent to which male and female students differ in their attitudes; (3) explore the extent to which the attitudes of students are different based on the level of education.

3.1. Attitudes and approaches to solving physics problems

This study investigates the attitudes and approaches of students at the junior high school, senior high school and college level in solving physics problems using the Attitudes and Approaches to Problem Solving (AAPS) instrument. The total mean score assigned to the AAPS was 3.30 points (SD = 0.75), on a scale of 1 to 5, with 1 being the lowest attitude and 5 being the highest towards problem solving. This means those respondents have an attitude and approach like an expert. These results are in line with previous studies [14], [15], [32], [34], [39]. Of the 35 items that make up the instrument, the one with the highest average (25) is "*If my answer doesn't make sense, then I think about the possibility of an error*." (M = 4.32; SD = 0.79), while the lowest (3) was "*math skills are the most important thing in solving physics problems*" (M = 1.64; SD = 0.77). This is in line with research which shows that students' attitudes tend to re-examine their answers and assume that math skills are very important which means they ignore concept understanding [32].

3.2. Analysis based on gender differences

The calculated total score obtained the mean and standard deviation of *M* male = 3.28, male SD = 0.24, and *M* female = 3.30, female SD = 0.24. No significant difference was observed between male and female students (t = -1.65 and Sig. = 0.098 > 0.05). The average score compared to all items by gender, showing differences in certain items. There were some differences in responses that were well received by men and women as in previous studies [32]. The average score of women is higher than that of men indicating that women show attitudes and approaches that are more expert than men in solving problems, these results are similar to those obtained in previous studies [14], [32], [33].

An analysis of gender differences by item showed that, of the 33 items on the AAPS, 7 items (10, 24, 3, 14, 5, 11 and 12) had statistically significant differences between the genders ($p < .05$). Items liked by women (10, 14, and 24), and things that men liked (3, 5, 11 and 12). This shows that male students are more likely to use mathematical equations by matching the problem with the appropriate equation and then entering the value to get the answer (3,5). Male students tend to use formulas to calculate answers and think irrationally (11) and assume that physics equations apply to certain situations (12). Female students are more likely to solve physics problems by thinking about appropriate principles and concepts and seeing reasonable solutions (10, 14), and girls like to work with friends when they encounter difficult physics problems (item 24). This result deserves to be re-examined because several studies on problem solving have shown that men are better problem solvers than women [34]. One of the reasons is the difference in the number of samples and the level of education used in this study.

3.3. Differences in education level

Table 1 provides an overview of the differences in attitudes and approaches in solving physics problems based on education level. The results of the average calculation show that college students' attitudes and approaches are higher than the others, and the lowest is the senior school level. The output of the ANOVA test, namely the Test of Homogeneity of Variances, provides information on whether there are similarities in score variations in each group of thinking styles. Based on the value of "p = sig." the value is greater than 0.05 (0.070) which means that the data meets the assumption of homogeneous variation.

Furthermore, based on Table 1, it provides information on statistically significant differences between each level of education ($p < 0.05$). The *p*-value (< 0.05) and the asterisk (*) showed that there was no difference between the level of education in junior high school (JHS) and senior high school (SHS). The education level of students was significantly different from that of JHS and SHS ($p < 0.05$).

Table 1. Mean Differences in Group by Education Level

Education level		Mean differences	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
JHS	SHS	,04049	,01989	,126	-,0072	,0882
	College student	-.09741*	,02039	,000	-,1463	-,0485
SHS	JHS	-,04049	,01989	,126	-,0882	,0072
	College student	-.13789*	,02543	,000	-,1989	-,0769
College student	JHS	.09741*	,02039	,000	,0485	,1463
	SHS	.13789*	,02543	,000	,0769	,1989

Analysis of each item showed a significant difference $p < 0.05$ based on education level. Items that have a difference between education levels are 24 items. Item (27) has a significant mean difference between all levels of education. The average college student acquisition is higher than the others. This shows that college students prefer to solve physics problems even though they are sometimes difficult. Junior and high school levels prefer to solve simple problems. The following discusses the differences in each item and trends based on the average responses on the AAPS instrument. Item 25 has a significant difference between junior and senior high school education levels. It offers different perspectives on exam and homework mistakes. Junior high school and college students are more likely to learn from their mistakes, so they will not make the same mistakes.

Items with different views between junior high school and college students are 6 items (3, 15, 17, 20, 30 and 33). Junior high school students do not consider mathematics to be the most important thing in solving physics problems. It should be inferred, as the use of mathematics to solve physics problems is less prevalent at the junior high school level compared to the college level (3).

College students find it helpful to solve physics problems by first drawing the situation described in the problem (15,17). After solving physics problems, they spend more time contemplating and studying (20). The junior high school level when solving physics problems using formulas/symbols is much more difficult than solving problems using numbers (30). College students are more likely to learn concepts first before solving physics problems (33). Based on this, it is reasonable to assume that junior high school students are given examples of questions and are not asked to learn the concepts first.

Items that have different views between high school students and college students are 4 items (4, 10, 28,29). When solving physics problems, I first identify the principles of physics before looking for a suitable equation. If I'm not sure how to solve a physics problem, then I think about the appropriate physics principle to see a reasonable solution. I tried different ways if one method didn't work when solving physics problems. If my answer to a physics problem doesn't make sense, then I retrace to see where it went wrong.

Items that have different views among JHS with SHS and college students are 6 items (5,8,9,12,19,24). The junior high school level thinks that solving physics problems is basically not just matching the problem with the appropriate equation and then entering the value to get the answer (5). But also, they assume that there is only one right way to solve problems in physics (8). The junior high school level tends not to use the same way to solve all physics problems, even though the situations given in the questions are very different (9). The junior high school level assumes that equations in physics only apply to certain situations (12). Junior school level students are more likely not to write elsewhere when answering multiple choice questions or essays (19). Junior high school students are more likely to do their own physics homework (24). Based on this, students at the junior high school level tend to use a simpler approach.

There are 6 items (1,2,7,14,18,26) that have different views between college students with junior and senior high school students. College students tend to try to solve physics problems before asking others (1).

They are more likely to make assumptions with the real world when solving physics problems (2) and think about the related variables in the equation then match it to the problem situation

(7). College students always think about the concepts in physics problems (14) and use pictures even though they are not needed to draw them (18). College students prefer to solve some difficult physics problems using a systematic way and then study them, rather than solving many easy and similar problems (26). The most basic difference is seen in how college students use better thinking processes when solving physics problems.

The attitudes and approaches to problem solving [36] instrument is the last series of previous instruments such as *Attitudes toward Problem Solving Survey* [13], dan *Colorado Attitudes about Science Survey* [3], developed by experts. The similarity of the findings of this study with previous studies implies that the Attitudes and Approaches to Problem Solving survey is a reliable survey that can be used to assess students' attitudes and approaches to solving physics problems.

The results of the research show that in general there is no difference in Attitudes and Approaches to Problem Solving. However, based on the items indicated that, there were several items that had statistically significant differences between the sexes ($p < .05$). Items favored by women are 10, 14, and 24, and those favored by men are 3, 5, 11 and 12. Based on this, special treatment is needed in learning physics by considering how they solve physics problems. For example, placing them into groups consisting of female and male students proportionally.

Based on the level of education, junior high school students have attitudes and approaches in solving physics problems that are better than high school levels. This needs to be a concern for high school students when carrying out classroom learning. High school students need to be emphasized to be more careful in solving physics problems. Different results with collect students who are more skilled in solving physics problems.

4. Conclusion

Based on the results of this study, it is recommended to investigate more carefully the attitudes and approaches to solving problems of women because there are inconsistencies between the findings in the literature. Second, examine the attitudes and approaches of physics students towards problem solving in several regions in Indonesia by comparing ethnic differences in each cultural context. Third, integrate the problem-based learning by considering its impact on learning outcomes and understanding of concepts and attitudes in physics lessons.

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