The Effectiveness of PBL Model Physics e-Book with STEMI Approach to Improve Student's Problem-Solving Ability in terms of Gender

Bahtiar [1*), Muhammad Kafrawi [2]
Universitas Islam Negeri Mataram, Indonesia[1,2]
*)**Corresponding E-mail: bahtiar79@uinmatara.ac.id**

Keywords :	ABSTRACT
e-Book; Problem-Based Learning; STEMI; Problem-Solving Ability	*The learning process that uses learning models and approaches that involve the active role of students can improve students' abilities. This study aims to analyze the effectiveness of the physics e-book PBL model with a STEMI approach to improve students' problem-solving abilities in terms of gender. In this quantitative study, a one group pretest-posttest approach was used. The research sample used was 55 class XI students of MA Hidayatullah Mataram, of which 25 were male students and 30 were female students. Collecting data on the effectiveness of using the problem-solving ability description instrument which consists of eight questions. Effectiveness data analysis used the N-Gain test and Rash model analysis. The results showed that male students dominated the IPSA-1 indicator (89.06) and IPSA-2 (68.23), while female students were more dominant in the IPSA-3 (89.19), IPSA-4 (76.35), and IPSA-5 (71.35). The results also showed that female students in all sub-subjects of work and energy had a higher average score than male students. In general, the results of the study also show that the PBL model physics e-book with the STEMI approach used in the learning process is effective in increasing the PSA of male and female students with an N-Gain score of 70.04.*

INTRODUCTION

The 21st century is synonymous with changes in cultural, social, political, economic, and educational aspects so that teachers can assist students in responding to the challenges of the times [1] [2]. Within the framework of the 2013 curriculum, Students must understand fundamental ideas and possess problem-solving abilities. This is in line with the difficulties of the twenty-first century, which include problem-solving, teamwork, communication, creativity, and innovation [3] [4].

Students' capacity for problem-solving enables them to accomplish tasks in the proper manner [5] [6]. The steps students take to solve problems show their problem-solving abilities [7] [8]. The results of the 2018 PISA survey show that the ability scores of Indonesian students in mathematics, reading, and science are ranked 5th from the bottom [9] [10] [11]. Based on findings from observations made in one of Mataram City's senior high schools, it was determined that (1) during the physics learning process, students did not really enjoy the learning delivered by the teacher, (2) students were busy with their respective activities in class without pay attention to the explanation of the material presented by the teacher, (3) the teacher conveys the material based on the material in the textbook without elaborating with problems in everyday life, and (4) when online learning takes place too, the teacher and students do not see any communication feedback in the learning process.

Results of interviews with teachers of physics-related courses further demonstrate that (1) in the learning process teachers use existing teaching materials such as textbooks that have been provided by the school, (2) teachers use learning models such as discovery, PBL, and PjBL, and (3) PSA of students in physics is still low. Research conducted by Jua et al [12], Wati et al [13], and Bahtiar & Ibrahim [14], also shows that students' PSA are still relatively low. The lack of PSA of these students illustrates that some students are less able to analyze and apply concepts in solving problems. In addition, applied learning has not facilitated students to have these skills [15] [16]. Offer ways to solve problems through five stages, namely problem identification, problem description, a concep of physics, mathematical stages, and conclusions. The ability to solve problems better requires engaging and interactive learning materials. Therefore, an electronic book is one of the learning tools required in the learning process.

E-books are online printed books that can be accessed through the internet in a structured way, where the material is in the form of links so that students can easily use it [17] [18]. The development of e-books must at least be in accordance with the principles of developing printed books which include the beginning, content, and closing [19] [20] [21] [22]. E-books have been widely used by students and teachers in learning physics, one of which is the Electronic School Book [23] [24].

The existing e-book does not contain things that can help students to learn independently. In addition, the e-book used does not contain models and learning approaches that facilitate active and independent learning [25] [26] [27]. The PBL (Problem Based Learning) approach is one of the concepts and methods that can be employed in the creation of ebooks [28] [29].

PBL is innovative and effective learning that can be used in education [30] [31] [32]. With the use of the PBL model, students are familiar with problems and can also study in groups [33] [34] [35]. Students are given the opportunity to undertake research and learn how to solve open-ended or real-world challenges using the PBL model [36] [37]. In addition to problem-solving, the PBL model does not only focus on problem-solving but also on the process of gaining experience, group collaboration, interaction, and social communication as professional competencies [38] [39]. The steps of the PBL model are (1) problem orientation, (2) learning organization, (3) investigation, (4) presentation of results, and (5) analysis and evaluation.

PBL is more meaningful if it is integrated with a learning approach that prepares students' life and career skills in terms of science, technology, mathematics, engineering, and religion [42] [43]. One of the integrated approaches is the STEMI (Science, Technology, Engineering, Mathematics, and Islamic) approach.

STEMI learning is learning by combining various fields of science that are juxtaposed with the real world [37] [44]. Students gain both information and skills concurrently in STEMI. Learning using STEMI can increase learning success and can help to think critically and creatively which is included in the function of applying 4C in the industrial revolution [45].

In general, the PBL model with STEMI provides full opportunities for students to be able to explore science, technology, engineering, mathematics, and religious values. This is something that becomes urgent in this research, namely that students are expected to; 1) to be able to comprehend the concept of physics in a concrete way with the abilities it has; 2) have good problem-solving skills, and 3) be able to connect the material being studied to Islamic principles.

In addition, this research is also important because it pays attention to gender in the learning process. The learning process will go well if there is good emotional control between male students and female students. Male students and female students have different characteristics and different brain structures [46] [47] [48]. This causes in the learning process both must have two different types. Bahtiar et al also stated that research with attention to gender needs to be conducted to determine the learning characteristics of male and female students [49]. Learning behavior is influenced by gender, because the biological abilities (brain) itself are different so that learning methods cannot be generalized [50] [51] [52].

The purpose of this study is to describe and evaluate the efficacy of physics e-books using the STEMI approach and the PBL model to enhance students' PSA in terms of gender. This research was conducted for three main reasons. First, students have difficulty interpreting the problem in the form of problem identification and expressing it in the form of a physics concept. Second, students have difficulty connecting the concepts obtained with religious values. Third, students have difficulty accessing online books that can facilitate students to think at higher levels. Thus, this study specifically answers: "Are the physics e-books based on the PBL model with the STEMI approach developed effective for improving students' problem-solving abilities in terms of gender?

METHOD

Types of Research
This research includes quantitative research. Quantitative research is research that presents data in the form of numbers presented in the form of tables and graphs. This research is a research that uses a one-group pretest and posttest design. The following is a presentation of the research design.
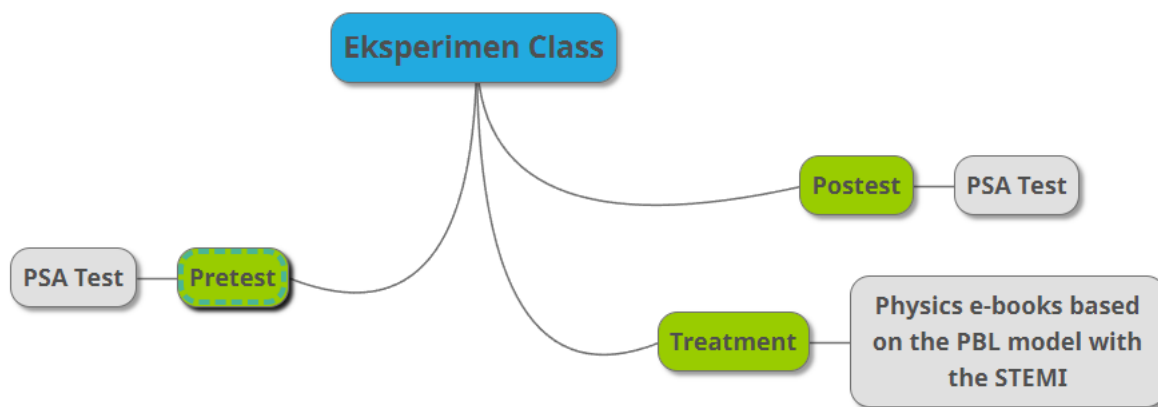
*Fig 1.* One-Group Pretest Postest Design

Research Participants
This research involved 55 class XI students of MA Hidayatullah Mataram. The number of participating male students was 25 people and female students were 30 people. This means that all class XI students at MA Hidayatullah Mataram were used as research samples. The following shows a percentage of the number of participants based on gender.
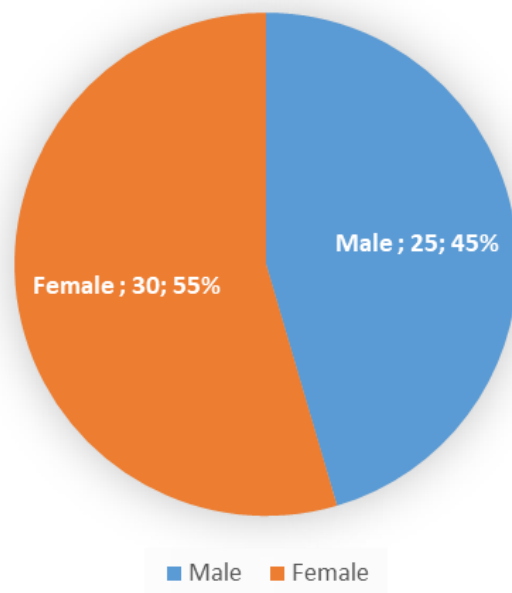
Fig 2. Research Participants Based on Gender

Research Procedure

The research conducted at MA Hidayatullah Mataram was conducted from August 2022 to October 2022. The research procedure is presented in the following figure.
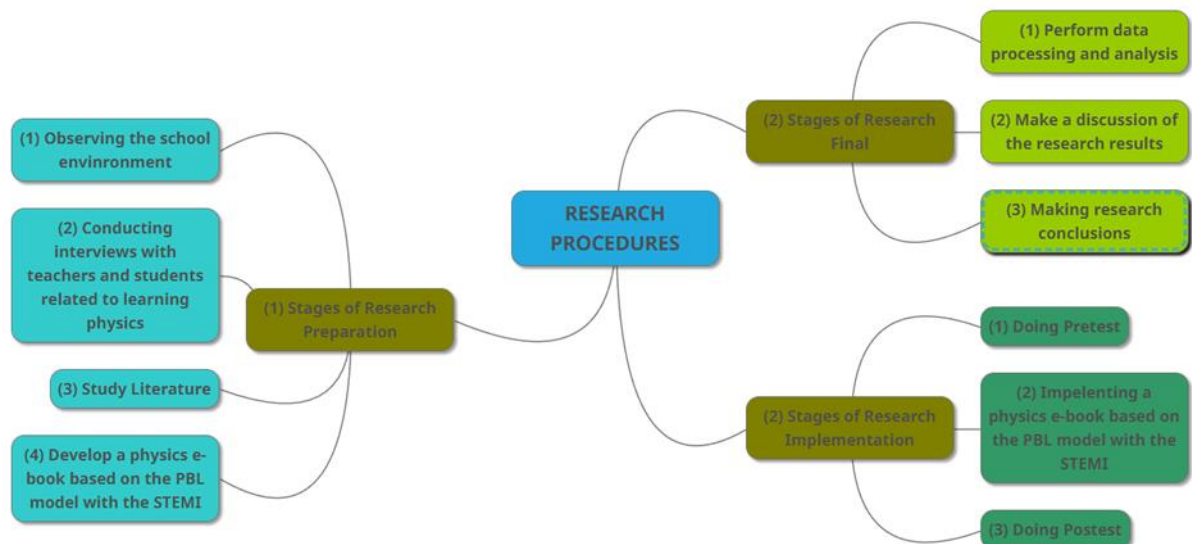
Fig 3. Research Procedures

Data Collection Instruments

The data collection instrument used in this study was an evaluation instrument in the form of a description of PSA. Data collection instruments are made based on indicators of PSA. The following presents a grid of instruments about PSA.
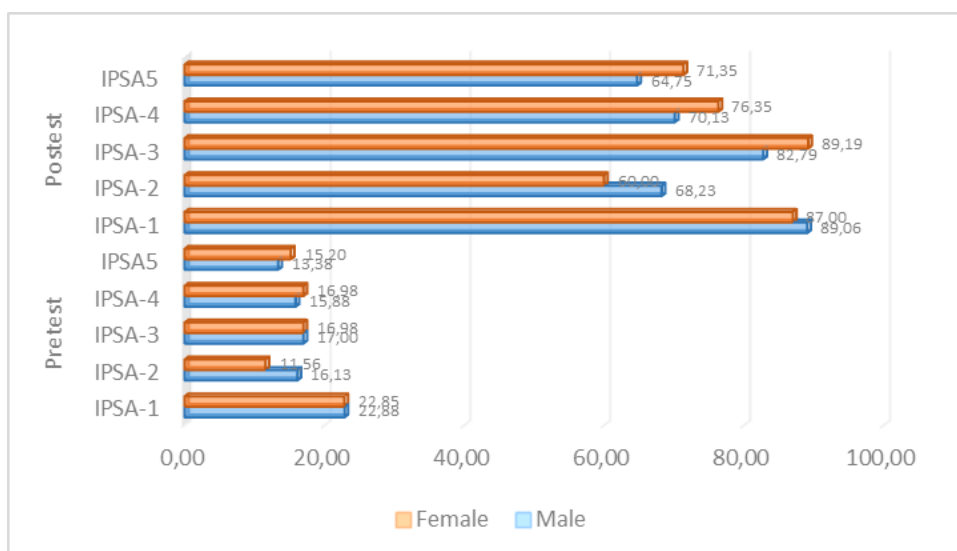
Table 1. Problem Solving Ability Grid

Indicators of Competence Achievement	Sub Material	Assessment Strategy			Question Number
		Method	Technique	Form	
3.9.1 Analyzing the business concept	Work	Test	Written	Description	Q1, Q2
3.9.2 Analyzing the concept of energy	Energy	Test	Written	Description	Q3, Q4
3.9.3 Analyzing the business relationship with energy changes	The relationship between work and energy change	Test	Written	Description	Q5, Q6
3.9.4 Analyzing the law of conservation of energy	Law of Conservation of energy	Test	Written	Description	Q7, Q8

Data Analysis Technique

Data on students' PSA that have been collected are analyzed in the form of descriptive statistics and N-Gain analysis. Descriptive statistical analysis using the Rash model (ministeps) and N-Gain analysis using Microsoft Excel.

RESULTS AND DISCUSSIONS

The PBL model physics e-book with the STEMI approach which has been revised based on the results of a limited trial was then re-tested in different classes at a wider trial stage. The purpose of the larger trial is to evaluate the performance of the created physics e-book application. The 55 students who were involved in the wider trial were divided into 25 male students and 30 female students over the course of three meetings. The test results data are broader including the initial test data and the postest of students' PSA. The initial ability data used in this study is the result data from the students' initial test before being given treatment, while the final ability data is obtained from the students' final test results. Based on the results of score tabulation and calculation of students' problem-solving ability tests for each problem solving indicator (IPSA), the percentage of IPSA-1 to IPSA-5 values is obtained as shown in Figure 4 below.

Fig 4. Problem Solving Ability Based on IPSA Viewed from Gender

Figure 4 above shows that the pretest and posttest results of male and female students reviewed for each problem-solving indicator are different. In the pretest results, male students were more dominant on the IPSA-2 indicator, namely describing the problem, while female students were more dominant on the IPSA-5 indicator, namely concluding the results of the solution logically. Figure 1 also shows that the posttest data obtained by male and female students are not much different for each indicator of problem solving. Male students dominate on the IPSA-1 indicator, namely identifying problems (89.06) and the IPSA-2 indicator, namely describing problems (68.23). The high problem-solving ability of male students on this indicator indicates that these male students are able to describe problems based on basic concepts, are able to make known quantity data, and are able to change problem identification into problem descriptions, and are able to draw diagrams/sketches that describe the problem. Female students were more dominant in the IPSA-3 indicator, namely the special application of physics concepts (89.19), IPSA-4, namely mathematical procedures (76.35), and IPSA-5, namely concluding the results of the solution logically (71.35). The high scores for each indicator obtained by female students indicate that female students are more able to determine physics equations that can be used in solving problems, are able to analyze problems using physics concepts, are able to substitute known quantities values using the selected physics equations, and are able to evaluate answers logically. In general, students' problem-solving abilities in terms of problem-solving indicators are presented in Table 2 below.

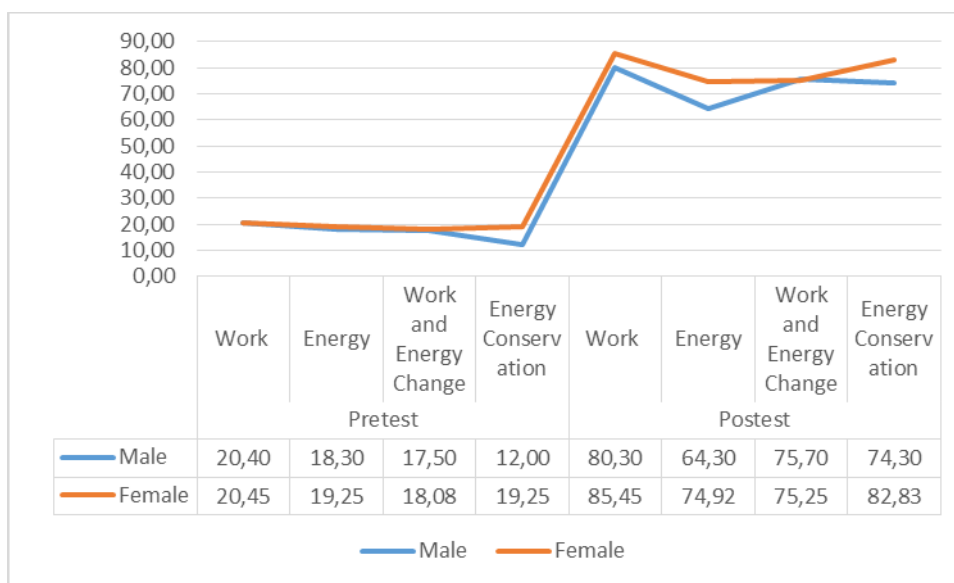**Table 2.** Average Percentage of Initial Test, Final Test, and N-Gain for Each Indicator

No.	Indicator	Average			Criteria
		Pretest	Postest	N-Gain (%)	
1	IPSA-1	22.1	85.0	80.7	High
2	IPSA-2	13.64	62.27	56.32	Currently
3	IPSA-3	17.0	85.6	82.7	High
4	IPSA-4	16.5	73.5	68.3	Currently
5	IPSA-5	12.8	68.4	63.7	Currently

Table 2 is the average percentage of PSA for each indicator and shows that in the IPSA-1 pre-test it got an average percentage value of 22.1%. Then for IPSA-2 it got an average percentage value of 1.64%, while for IPSA-3, IPSA-4 and IPSA-5 respectively it was 17.0%, 16.5%; and 12.8%. Based on the results of the percentage value of the average PSA for each problem-solving indicator (IPSA) on students' initial tests, it was found that all HDIs were classified as low. The low average score of the initial test of problem-solving abilities of male and female students on all indicators is because students have not received the material for effort and energy as a whole, students have not encountered the type of problem-solving ability questions in their schools, and students have not studied when the initial test was carried out. The average percentage of problem-solving ability for each final test indicator in both classes, which is in the high category for IPSA-1 and IPSA-3, and moderate for IPSA-2, IPSA-4 and IPSA-5.

Table 2 also shows that in the final test the HDI that got the highest percentage was IPSA-3, which was 85.6%, while the HDI that got the lowest score was IPSA-2, which was 62.27. IPSA-1 and IPSA-3 are in the high category for both male and female students. This is because IPSA-1 and IPSA-3 are indicators of problem identification and specific application of physics concepts. The researcher defines problem identification as the ability of male and female students to list the known quantities and the quantities asked for each question, while the specific application of physics concepts is the ability of students to determine the correct equation for problem solving. In the learning process, male and female students are accustomed to working on group worksheets, and in these worksheets, male and female students are asked to be able to understand, state that they are known and asked about each question, and conduct experiments as a form of concept application. physics. This is supported by Bahtiar et al who state that an important component in solving physics problems is identifying the relevant physical principles contained in the problem [8]. There are three IPSA in the moderate

category, namely IPSA-2, IPSA-4, and IPSA-5. The results of this study are also strengthened by research by Gunawan et al which states that problem solving indicators have increased, but the least increase is IPSA-2 [53]. This is because students do not involve components that affect each of the PSA components. In addition, students find it somewhat difficult to make representations in the form of graphs, diagrams, or verbally during learning and when solving problems during tests. Both male and female students make image representations only if they feel necessary in solving the problem. If the problem is simple (substitution of numbers into formulas) or the questions are equipped with pictures, male and female students do not make representations of these images. Students also do not sequentially carry out mathematical operations properly. The ability to rewrite logical conclusions (IPSA-5) has been possessed by students, although not completely. Students still forget to write down units, and even conclusions from the completion that has been done.

The results of the N-Gain test show that students' PSA has increased. The N-Gain test findings revealed that IPSA-1 had the largest increase of all the indicators, with an N-Gain percentage of 80.7% in the high category. While the indicator with the lowest increase is IPSA-2 of 56.32% in the medium category. The increased ability to solve problems for each indicator is due to student-centered learning and male and female students are asked to find answers to these problems so that students explore more deeply to solve these problems. In addition, male and female students at the beginning of learning are given a problem that is followed by worksheets and teaching materials, this is intended so that students can understand the concept so that students' understanding is more meaningful and results in increasing students' problem-solving abilities for each indicator. The findings of this study are supported by research by Ibrahim et al, which claims that student-centered learning and asking students to research topics in-depth before coming up with solutions improves their problem-solving skills [54]. The PSA data is also subject to sub-material analysis to find out the improvement. The following presents the pretest posttest data for each sub-material based on gender.

	Pretest				Postest			
	Work	Energy	Work and Energy Change	Energy Conservation	Work	Energy	Work and Energy Change	Energy Conservation
Male	20,40	18,30	17,50	12,00	80,30	64,30	75,70	74,30
Female	20,45	19,25	18,08	19,25	85,45	74,92	75,25	82,83

Fig 5. *Problem Solving Ability Based on Sub-material Viewed from Gender*

Figure 5 demonstrates how the sub-materials used for the pretest and posttest reveal different things about the students' problem-solving skills for both male and female students. In every sub-subject of labor and energy, female students perform better on average than male pupils. This indicates that female students have better PSA in the material of work, energy, changes in work-energy, and the law of conservation of mechanical energy. Female students are able to analyze material problems in energy work by relating them to everyday life and Islamic views. In general, students' PSA in terms of sub-material are presented in Table 3 below.

Table 3. Average Percentage of Initial Test, Final Test, and N-Gain for Each Sub-Material

No.	Sub-material	Average			Criteria
		Pretest	Postest	N-Gain (%)	
1	Work	15.09	75.32	70.93	High
2	Energy	16.73	70.09	64.08	Currently
3	Work and Energy Change	17.82	75.45	70.13	High
4	Energy Conservation	15.95	78.95	74.96	High

According to Table 3, the average initial test resulted in a 17.82 average score in the business & energy change sub-material and a 15.09 average score in the business sub-material. The law of conservation of energy sub-matter received the highest average final test score (78.95), while the energy sub-matter received the lowest average final test score (70.09). Each sub-material's average N-gain score in PSA has gone up. The sub-matter of energy conservation law saw the highest increase (74.96%), while the sub-matter of energy saw the lowest increase (64.08%).

Due to students' active participation in the learning process, this sub-average material's N-gain value is higher than usual. This is evident from the pupils' eagerness to solve the issues set by the teacher during the problem-orientation stage of the LKPD. Additionally, the teaching materials frequently discuss the sub-materials for work, work & energy changes, and the law of the conservation of mechanical energy. Analysis of the energy sub-matter places it in the same medium category. This is due to the fact that the sub-material covered in the second meeting comprises of two discussion topics, kinetic energy and potential energy. In spite of 120 minutes of instruction on these two topics, students still failed to grasp the fundamental idea presented in the motion content. This makes it difficult for them to understand speed, one of the key elements of kinetic energy.

According to research by Gunawan et al, which found that students' problem-solving skills for each sub-material of work and energy are in the medium-high range, the results of increasing PSA for each sub-material of students are in agreement with that finding [53]. Research by Nisyah et al also showed that each of the work and energy sub-materials experienced a significant increase [55]. The application of the PBL learning model with the STEMI approach is very appropriate, students are directed to solve problems in everyday life related to STEMI content. In the following, pretest data is presented on the problem-solving abilities of male and female students in general.
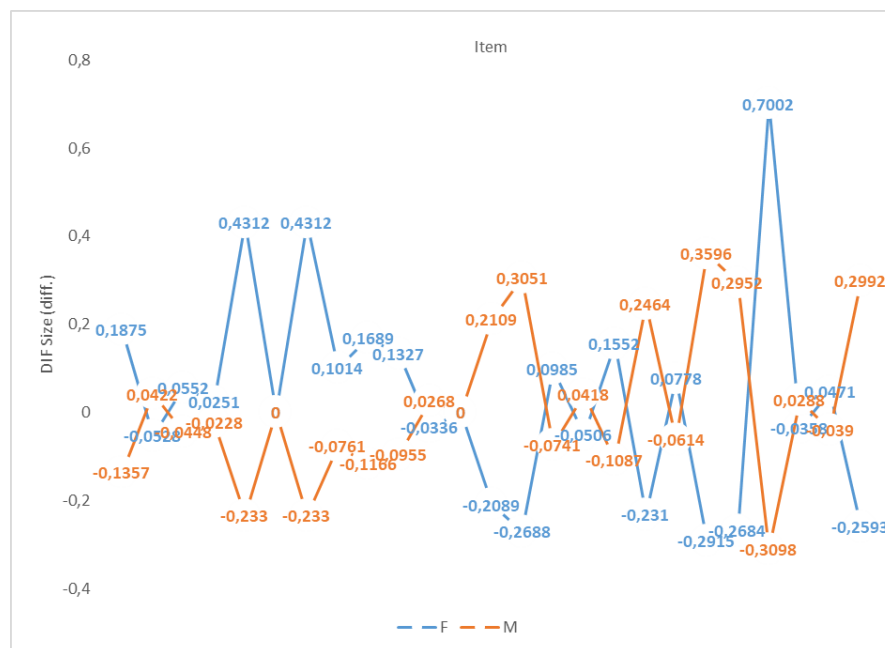
*Fig 6. Distribution of Students' PSA Ability Based on Gender*

Figure 6 shows the distribution of the PSA pretest abilities of male and female students which were analyzed using the person DIF plot based on the rash model. In the picture above it can be seen that the logit values obtained by male and female students are between -0.3098 and 0.7002. This shows that in these items, female students find it easier to solve material problems of work and energy than male students. On other item items with a logit value of -0.2688 with 0.3051 indicating that male students are easier to answer questions on that item than female students. The following figure also presents a comparison of the PSA of male and female students during the pretest.

Fig 7. *Comparison of PSA of Male and Female Students*

Figure 7 shows that the PSA of male and female students at the posttest have a higher logit score than at the pretest. Female students' logit values are higher than male students' logit values. This suggests that female students are capable of resolving work and energy issues connected to Islamic content at the time of the posttest. Improved PSA in general which can be seen in Figure 8 below.
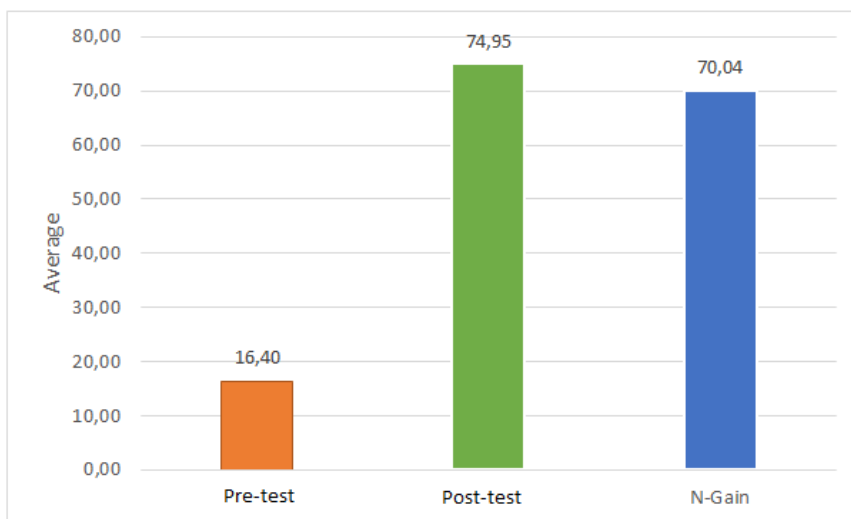
Fig 8. *Average Pretest, Final Test, and Increase in Student PSA*

According to Figure 8 above, students' average PSA before receiving treatment were 16.40, while their average PSA rose to 74.95 after receiving treatment. The average N-gain score of 70.04 reflects this rise as well. The average increase in PSA of these students is included in the high category. The N-gain score in the high category is due to the application of the PBL learning model with the STEMI approach in learning. The PBL learning model is a teaching model designed with the aim of helping students develop thinking skills and developing abilities in solving everyday life problems. Through the PBL learning model students are given the opportunity to seek information through experimental activities facilitated through LKPD and teaching materials.

This is proven by the active role of students in working on LKPD and seeking information through teaching materials during learning. The LKPD contains five problem solving indicators. Each of these indicators supports the active role of students to solve them in an effort to analyze how these phenomena occur, what causes them, and how these phenomena are resolved. Research by Yorganci, which claimed that lessons taught utilizing the PBL learning model had an impact on students' problem-solving skills, further supported this [26]. According to research by Simamora et al, using the PBL learning paradigm can improve students' problem-solving skills and learning activities [56]. Additionally, research by Amalia et al found that employing the PBL model increased students' capacity for problem-solving [57].

The STEMI approach, in addition to the PBL learning paradigm, has an impact on the rise in the N-gain value. The STEMI approach combines Islam with science, technology, engineering, and mathematics. To help pupils develop their problem-solving skills, many teaching strategies are combined [58]. This was further supported by research by Apriyani et al, which found that using the issue integration model and project-based learning in STEM-based learning improved students' PSA [59].

CONCLUSION AND SUGGESTION

Based on the discussion and description of the research findings, it can be stated that the PBL model physics E-book with the STEMI approach is utilized in an effective learning process to increase the problem-solving abilities of male and female students with an N-Gain score of 70.04.

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