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Research Artikel

COMPARISON OF THE POE2WE MODEL'S EFFECTIVENESS WITH THE 5M SCIENTIFIC APPROACH TO PROBLEM-SOLVING ABILITY IN SIMPLE HARMONIC MOTION

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Abstract

This study aims to determine the implementation of learning, improvement, and differences in problem-solving abilities among students who learn using the Prediction, Observation, Explanation, Elaboration, Writing, and Evaluation (POE2WE) models aided by PhET simulation and scientific approach aided by Amrita Olab Edu. The noneequivalent control group design was used in a quasi-experimental design. The sample consists of 31 students from classes X MIPA 2 and X MIPA 3 at one of Tasikmalaya's senior high schools. A student worksheet with SAS and a problem-solving ability test were used as instruments. The SAS sheet analysis results show that the average learning implementation in the experimental class is 78.9% in the effective category, while the control class is 75.9% in the effective category. Based on the N-gain, the experimental class improved students' problem-solving abilities by 0.73 in the high category, while the control class improved by 0.62 in the medium category. The t-test results revealed that the t_{count} (4.66) > t_{table} (2.00) and the sig. (2-tailed) 0.000018 indicate differences in the problem-solving abilities of students who learn using the POE2WE model and the scientific approach 5M on simple harmonic motion material. The POE2WE model can train and improve students' problem-solving abilities.

Keywords: *POE2WE model; 5M scientific approach; problem solving ability; simple harmonic motion.*

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INTRODUCTION

The world that is overgrowing and complex in the 21st century is aimed at improving the quality of people's lives (Pratiwi, Cari, & Aminah, 2019). It includes all aspects of the order of life, including in the fields of transportation, economy, technology, communication, information, and so on. (Monica, 2021). It is necessary to have superior human resources to face the new demands of the 21st century through education (Putra, Saputra, & Wardana, 2021).

Education in the 21st century has an essential role for students to have knowledge skills, learning skills, attitudes, and mastery of information technology (Ayu, 2019). 21st-century learning skills include critical thinking and problem solving, communication, collaboration, creativity, and innovation. (Trilling & Fadel, 2009). The problem-solving ability has thus become one of the essential skills it improved in the physics learning process in schools (Ince, 2018). The ability helps students in solving physics problems related to everyday life. Students can have meaningful experiences and be active in teaching and learning activities (Ayudha, & Setyarsih, 2021).

The problem on problem solving ability was proved by previous research. Study in Mataram found that students' problem-solving abilities were still relatively low (Noviatika, Gunawan, & Rokhmat, 2019). Research by Yulianawati et al (2018) at one school in Bandung, the value of students' problem-solving abilities was still below the expected, namely the average score of 8.27 out of a maximum total score of 36. It is reinforced by research by research by Zahra, Matius, & Hakim (2018) the average increase of students in one of the school in Samarinda in the problem-solving ability of simple harmonic motion material in the low category with the acquisition of N-gain 0.2.

A preliminary study through interviews with physics teachers at one of the schools in Tasikmalaya found that problem-based learning activities that have been applied are more focused on solving physics in helpful descriptions and mathematical physics. The interviews with students found that learning leads more to completing mathematical procedures. Students with this experience difficulty applying the formula to each question because they do not fully understand the physics concept. The questionnaire results found that 68.67% of students found it challenging to understand physics, and 71.3% of students agreed that they could not design physics problem-solving. The results of learning observations indicate that the teacher dominates the activity in the classroom, and not all students take an active role in solving the problems given by the teacher. Learners in learning lack practice in problem-solving. It is reinforced by the test results of problem-solving on simple harmonic motion material, which refers to the five indicators of Docktor & Heller (2009) It is still in the low category, with an average of 39.98%. Based on this, it is necessary to improve the learning process in the classroom to develop students' problem-solving abilities.

One effort to train problem-solving skills is using the stages of the prediction, observation, explanation, elaboration, writing, and evaluation (POE2WE) model in learning. The POE2WE learning model is structured so that learning is centered on students (Ahmad et al, 2020). The model can provide opportunities for students to play an active role in learning, construct knowledge independently, and make observations of a problem or phenomenon. (Nurnazarudin et al, 2020), communicate the results either orally or in writing (Herdiani, 2020). The POE2WE model can make students interested and make the learning atmosphere not monotonous and boring (Nana, 2019).

The characteristics of the POE2WE model are that it provides opportunities for students to construct their knowledge and communicate the results. It can also train students to be independent in the learning process (Pratama et al, 2021). The social system in learning that applies the POE2WE model according to Purba, et al (2021) includes interactions with teachers. The teacher acts as a moderator and facilitator in designing and implementing learning. Social interaction is where students prepare for group learning and provides mutual benefits between one student and another—finally, interactions in the student worksheet equipped with instructions. This POE2WE model has several advantages. It can make students active in learning, familiarize them with building and discovering their knowledge, facilitate them in developing critical thinking skills and solving their problems, and encourage them to develop their courage. Pouring ideas or ideas they have, as well as training students on communication skills (Nana, 2019).

Previous research found that the POE2WE learning model affected students' interests and learning outcomes. (Enrizal, Putri, & Muhartati, 2022). Research conducted by Nana (2020) shows that the POE2WE model based on virtual experiments can train students' science process skills on collision material. The research results by Mubarok, Nana, & Sulistyaningsih (2020) showed that the POE2WE model based on hands-on activity effectively improves critical thinking skills and active social interactions. It is related to Nana & Surahman (2020) research that the POE2WE model can be alternative learning in the 4.0 revolution era. Hence, this study try to analyze the difference the POE2WE model helped by PhET Simulation and the 5M scientific approach stages helped by Amrita Olab Edu in improving students' problem-solving skills on simple harmonic motion material.

The primary purpose of this study was to determine the implementation of learning, improvement, and differences in problem-solving skills among students. Who learn by applying prediction, observation, explanation, elaboration, writing, and evaluation (POE2WE) models with PhET Simulation and 5M scientific approach assisted by Amrita Olab Edu.

METHOD

The research used a quantitative approach and a quasi-experimental design. Nonequivalent Control Group Design became the design used in the study. (Hardani et al, 2020). First, an initial measurement (pretest) on students' problem-solving ability, then gave treatment to the experimental class by applying the POE2WE model assisted by PhET Simulation and control class using the 5M scientific approach assisted by Amrita Olab Edu. The treatment was conducted in five meetings with 2 meeting as pre and post test. The final stage is to re-measure students' problem-solving abilities (posttest). The research subjects were 31 students of class X MIPA 2 and X MIPA 3, as many as 31 people at one of the senior high schools in Tasikmalaya. The sampling technique used was the cluster random sampling technique.

This study used the student worksheet with SAS containing questions or quizzes on simple harmonic motion material to record the implementation of learning activities from introduction to closing (Azzahra, 2022; Nuryantini, et al., 2020). The data obtained is calculated using the Authentic Assessment Based on Teaching and Learning Trajectory (AABTLT) with Student Activity Sheets (SAS) scoring rubric, which has a range of 0-4 is presented in Table 1.

Table 1. AABTLT Assessment Rubric with SAS

Score	Criteria
4	If the answer is appropriate or perfect
3	If the answer given is correct, and complete but not perfect as expected
2	If the answer given is correct but incomplete
1	If the respondent gives a wrong answer
0	If the respondent does not provide an answer

The test instrument is used to measure the problem-solving ability of students based on five indicators and aspects, according to Docktor & Heller (2009). These five indicators are useful descriptions, physics approaches, specific physics applications, precise mathematical procedures, and logical progressions.

Expert lecturers (expert judgment) validated learning tools and test instruments covering content, language, and constructs. The problem-solving test instrument was tested and then analyzed. It used the validity, reliability, level of difficulty, and discriminating power through calculations using software anatest. The instrument quality was showed by the average validity $r_{count} > r_{table}$ and the reliability 0.912.

The implementation of the model was analyzed based on the learning effectiveness criteria presented in Table 2 (Mulhayatiah, Agnia, & Suhendi, 2021).

Table 2. Criteria for Learning Effectiveness

Percentage Score	**Interpretation**
> 85%	Very effective
71% – 85%	Effective
55% – 70%	Less effective
< 55%	Not effective

The pretest and posttest data were calculated to look for the N-gain value. The N-gain value obtained is interpreted using the criteria in Table 3 (Hake, 1998).

Table 3. Criteria N-*gain*

Percentage Score	**Interpretation**
$\langle g \rangle < 0,3$	Low
$0,7 > \langle g \rangle > 0,3$	Medium
$\langle g \rangle > 0,7$	High

The test results are also used for hypothesis testing.tests include normality test and homogeneity test performed by first to determine hypothesis testing. The prerequisite test is met, namely the data is normally distributed and homogeneous, so the hypothesis is tested using the independent sample t-test.

RESULTS AND DISCUSSION

The choice of syntax from the POE2WE learning model and indicators of problem-solving abilities as follows. Prediction stage, at this stage students observe the phenomena presented by the teacher in the form of videos or pictures. Then describe and write down important information and make predictions based on the problems that have been observed. Indicators of problem-solving abilities trained at this stage are useful descriptions where students can describe important information obtained from the results of observing activities. Another capability is the physics approach where students can make predictions from the questions given.

Observation Stage, at this stage students will look for solutions or make answers to questions by holding discussions with groups. The problem-solving indicator being trained is a physics approach where students will select relevant physics concepts and principles to use in solving problems. Explanation Stage, at this stage the teacher guides students to important explanations and provides instructions for making observations so they can prove physical quantities directly. The problem-solving indicators trained are specific physics applications where students can determine solutions based on more specific physics concepts and principles through experiments

Elaboration stage, at this stage students apply understanding of concepts and problem-solving strategies that have been obtained in new situations or other related problems, so that students better understand the concepts being taught. The indicators that are trained are the use of appropriate, correct, and appropriate mathematics based on experimental data. Write stage, at this stage students write down the results of the activities that have been carried out by making conclusions and reports from the results of the experiments that have been carried out. The problem-solving ability indicator being trained is logical progression.

Evaluation stage, at this stage an evaluation of learning is carried out including knowledge, skills and changes in students' thinking processes in the form of oral and written. The indicator of problem-solving ability that is trained is logical progression, where students will evaluate the learning outcomes that have been carried out so that students' problem-solving abilities are more progressive.

The average implementation of learning using the POE2WE model in terms of students' answers on the SAS sheet for three meetings is shown in Table 4.

Table 4. Data on Average Implementation of POE2WE Learning with *PhET Simulation*

Meeting to	Percentage of Execution (%)	Interpretation
1	72.0	Effective
2	79.4	Effective
3	85.4	Very effective

The implementation of learning using the POE2WE model with PhET Simulation increased at each meeting. The lowest percentage was at the first meeting, with a percentage of 72% in the effective category. It is because there are several stages that students do not understand and require teachers to re-explain and guide students. One example is at the elaboration, where students are not accustomed to processing experimental data and confusion in data analysis and mathematical equations presented in filling out questions. The guides given and the teacher at the first meeting was not optimal in managing time, so learning was rushed (Kartini, Bahar, & Elvinawati 2021). The most significant percentage was at the third meeting, with a percentage of 85.4% in the very effective category. It shows that students are used to following the teacher's instructions and the performance of students and teachers. There is a good improvement in carrying out each stage of learning. The learning procedures developed in this model are easy to follow and understand (Nana, 2019).

The implementation of learning activities using the stages of the POE2WE model is presented in Table 5.

Table 5. Implementation of Stages of POE2WE with PhET Simulation

Stages	Meeting to-			Average	Interpretation
	1	2	3		
Prediction	75.8	76.2	86.3	79.4	Effective
Observation	76.2	83.9	84.7	81.6	Effective
Explanation	86.3	89.5	90.3	88.7	Very effective
Elaboration	65.1	81.5	87.5	78.0	Effective
Write	64.5	76.6	78.2	73.1	Effective
Evaluation	69.4	74.2	88.7	77.4	Effective

According to Table 5, the highest value is at the explanation stage of 88.7%, with a very effective category. It is because students can effectively explain the findings, actively express their opinions, and carry out experimental activities based on the problems presented. Widiastuti et al (2022) said practicum is an activity that is suitable or suitable for concept discovery through a process that will bring up skills such as discussion and problem solving and become an interesting learning method. So that means learning outcomes are obtained in the form of attitudes, knowledge, and skills. The lowest value is at the write of 73.1%, with a less effective category. It is because some students at the initial meeting felt that the time given was still not enough. So, at this stage, there were still some that did fill out, and students were not confident in summarizing the conclusions of the lesson in writing. Not all students can write conclusions well (Juita, Gita, & Yusmaridi, 2020).

The advantage of the POE2WE learning model is that it can motivate student problem-solving. So that students can express ideas or ideas in learning and help improve problem-solving skills through several stages. Such stages encourage students to make predictions from problems and solve these problems. Students can elaborate knowledge on new related issues through observation and observation activities. The learning process in this model can encourage the independence of students in learning and develop students in the insight and mindset about the knowledge they have (Marbun, 2021). Nana (2020) said the drawback is that the learning process using this model takes a long time, so there are still fewer than optimal stages.

The average implementation of learning using the 5M scientific approach for three meetings is presented in Table 6.

Table 6. Implementation of 5M Scientific Learning with of *Amrita Olab Edu*

Meeting to	Percentage of execution (%)	Interpretation
1	72.0	Effective
2	79.4	Effective
3	85.4	Very effective

The implementation of learning using the stages of the 5M scientific approach increases at each meeting. The lowest percentage at the first meeting was 70.2% in the less effective category. The smallest value supports this result at the first meeting, namely the associating stage; students are not accustomed to processing data and presenting graphs or results in the questions. Some group members tend to be passive, so they cannot adjust to other group members (Yaspin, Ahmad, & Sari, 2018). The most significant percentage is at the third meeting, with a percentage of 80.9% in the effective category.

The implementation of learning activities using the 5M scientific approach stages is shown in Table 7.

Table 7. Implementation of Each Stage of the 5M Scientific Approach

Stages	**Meeting to-**			**Average**	**Interpretation**
	1	**2**	**3**		
Observe	68.5	78.2	87.9	78.2	Effective
Ask	69.4	70.2	70.2	69.9	Less effective
Try	75.0	83.1	88.7	82.3	Effective
Associate	64.9	77.8	83.1	75.3	Effective
Communicate	65.3	72.6	73.4	70.4	Less effective

In the effective category, the highest stage of 5M scientific learning is at the trying stage of 82.3%; students are orderly and directed in practicum activities according to the guidelines. Group collaboration has also been successful; each student collaborates to complete practical assignments and answer multiple questions. (Yaspin, Ahmad, & Sari, 2018). The lowest stage is at the communicating stage of 70.4% in the less effective category. It is because students are still not used to formulating problems or answering questions based on their knowledge (Rosida & Erman, 2021).

The advantages of learning by applying the 5M scientific approach to research are creating more learner-centered learning. Students are active in constructing a concept or principle and can stimulate intellectual development, especially in higher-order thinking skills. The drawbacks of conducting research are that it requires careful preparation and good teacher creativity. Rhosalia (2017) not all materials can match using the 5M scientific approach, so more creative teachers are needed to deal with deficiencies in this case.

The results of students' problem-solving abilities after taking tests in the experimental class using the POE2WE stage assisted by *PhET Simulation* and the control class using the 5M scientific approach stage assisted by *Amrita Olab Edu* are shown in Table 8.

Table 8. N-*gain* Experiment and Control Class

Class	**Pretest**	**Posttest**	**N-gain**	**Interpretation**
Experiment	34.28	82.06	0.73	High
Control	34.11	74.87	0.62	Medium

The experimental and control classes have nearly the same initial ability, and both have an average value in the low category; specifically, the experimental class receives a score of 34.28, and the control class receives a score of 34.11. The average posttest value differs between the experimental and control classes. The experimental class has a higher average percentage value of 82.06 than the control class, which has a value of 74.84. The N-gain results show that the experimental class has a higher value than the control class. After applying the POE2WE model, the N-gain obtained in the experimental class is 0.73, which is included in the high category or increased posttest in the high category. Students are used to every learning process using the POE2WE model and fill out each stage of learning well. The POE2WE model, which aligns with problem-solving indicators on simple harmonic motion material, was used to train students in problem-solving skills. It is in line with the research results of Mubarok, Nana, & Sulistyaningsih (2020) that the POE2WE learning model actively involves the learning process and can be an alternative to training higher-order thinking skills in physics learning.

The overall N-gain in the control class was 0.62 in the medium category or experienced an increase in posttest in the moderate category after the 5M scientific approach was applied. It is because there are still several stages that are lacking and in line with research conducted by Pitaloka & Suyanto (2019) that learning by applying the 5M scientific approach obtained a pretest of 35.86 and a posttest of 54.91, so the average N-gain solution student problems of 0.29 in the low category.

Table 9 shows the average values of pretest, posttest, and N-gain for each sub-material of simple harmonic motion.

Table 9. Average *Pretest, Posttest* and N-*gain* Each Sub-Material

Sub Material	Experiment		Control	
	N-*gain*	**Category**	**N-*gain***	**Category**
Harmonic motion on a spring	0.7.6	High	0.62	Medium
Harmonic motion on a pendulum	0.69	Medium	0.58	Medium
Simple harmonic motion energy	0.74	High	0.65	Medium
Average	0.73	High	0.62	Medium

The highest N-gain value in the class experiment, namely on the harmonic motion sub-material on the spring of 0.76 in the high category, and the lowest on the harmonic motion sub-material on the pendulum was 0.69 in the medium category. The material for harmonic motion in springs is easy to understand and systematically trained in problem-solving skills presented through life events closely related to the material. While in the second material, there are still concepts that are sometimes backward in understanding, or there are still concepts that are still not adequately understood, so students are less than optimal. Some students' understanding of the relationship between the rope length and the pendulum's period is still lacking, and they feel confused (Husniyah, Yuliati, & Mufti, 2016).

The highest N-gain is in the control class, 0.65 in the medium category's sub-material of simple harmonic motion energy, and the lowest is 0.58 in the sub-material of harmonic motion on the pendulum with the medium category. The problem in the third material given is closely related to everyday life. The core concepts of learning in this sub-material have been studied a little in the previous related material. It is in line with the research of Zaenab and colleagues that the highest level of problem-solving for students is in simple harmonic motion energy material (Zaenab, Makhrus, & Gunada, 2019). While in the second material, there are still concepts that students do not understand correctly, so it is not optimal as expected.

Table 10 shows the improvement in students' problem-solving abilities in each simple harmonic motion material as measured by the five indicators.

Table 10. Average Pretest, Posttest and N-gain Each Indicators

Indicator problem-solving	Experiment		Control	
	N-*gain*	**Category**	**N-*gain***	**Category**
Useful description	0.77	High	0.63	Medium
Physics approach	0.78	High	0.59	Medium
Specific physics Apps	0.80	High	0.66	Medium
Proper mathematical procedure	0.65	Medium	0.55	Medium
Logical progression	0.68	Medium	0.66	Medium
Average	0.73	High	0.62	Medium

The highest average N-gain in the experimental class is 0.80 on a specific physics application indicator with a high category. In line with the research conducted by Mufida & Setyarsih (2019) the problem-solving ability scores for specific physics application indicators were also found to be in the very good category. In the medium category, the lowest value on the correct mathematical procedure indicator is 0.65. This is because some students continue to struggle with applying mathematical formulas to the given problem.

In the meantime, the highest score in the control class was 0.66 for specific physics application indicators and logical progressions in the medium category. Students are used to solving specific problems using logical progressions. In the medium category, the lowest value on the indicator of the mathematical procedure is 0.55. It is because there are still flaws in mathematical operations, for example, some missing steps or errors in selecting a formula or entering a value into it. It is consistent with Nora and colleagues' research, which discovered that students' application of the concept to calculations was still low (41.4%) (Susiana, et al, 2017).

A prerequisite test was used to determine the difference in average problem-solving ability between the experimental and control classes. Normality and homogeneity tests are required as prerequisites. Table 11 shows the normality test, and Table 12 shows the homogeneity test.

Table 11. Recapitulation of the Normality Test for the Experimental and Control Classes

Category	**Experiment**		**Control**	
	Pretest	***Posttest***	***Pretest***	***Posttest***
Testing	0.102	0.108	0.050	0.200
Description	normal distribution	normal distribution	normal distribution	normal distribution

The normality test calculation result was obtained from the pretest and posttest in the experimental and control classes using the Kolmogorov-Smirnov test. The results showed that the pretest in the experimental class was 0.102 and the posttest was 0.108, indicating that the data were normally distributed. The pretest data in the control class is 0.050 greater than or equal to 0.050, and the posttest data is 0.200 greater than 0.05, indicating that the data is normally distributed.

Table 12. Recapitulation of Homogeneity Test

Category	***Pretest***	***Posttest***
Sig.	0.964	0.410
Results	Sig. > 0.05	Sig. > 0.05
Interpretation	Homogen	Homogen

The data from the homogeneity test results from the pretest and posttest from the experimental and control classes are 0.964 > 0.05 and 0.410 > 0.05, respectively, indicating that the data in both classes are homogeneous. The results of the data normality test are normally distributed, and the data homogeneity test is homogeneous, so the hypothesis testing is a t-test independent sample test. Table 13 displays the hypothesis test results.

Table 13. Hypothesis test results

Category	**Score**
T_{count}	4.66
T_{table}	2.00
Sig.(2-*tailed*)	0.000018
Criteria	Ha accepted and Ho rejected
Description	There are differences in the problem-solving abilities of students

The t independent sample test yielded the following results: t_{count} (4.66) > t_{table} (2.00) and sig.(2-tailed) 0.000018 < 0.05. There are differences in the problem-solving abilities of students who study using the POE2WE model and the 5M scientific approach on simple harmonic motion material, according to Ha's criteria and Ho's rejection. The improvement in students' problem-solving abilities in the class using the POE2WE stage with the high category is greater than the improvement in students' problem-solving abilities in the class using the 5M scientific approach stage with the medium category. It is because almost all indicators of problem-solving ability using the POE2WE model are greater than those of learning using the 5M scientific approach. the POE2WE model can be an alternative in training students in higher-order thinking skills (Fajriyah & Jatmiko, 2021). Thus, the POE2WE can be optimized to improve student problem-solving ability in simple harmonic motion topics.

The research's limitations are at the stage of evaluating the POE2WE model in class experiments. Stage communication on the 5M scientific approach is under the control of the class. Both stages should be completed orally by each group, not only in writing, and represented verbally by people. In further research the teacher should be able to guide students to be more confident in communicating in writing. While the lowest stage of learning using a scientific approach is at the communicating stage in which there is a process of conveying the results of the analysis or evaluation from the previous stage. Future research is expected to pay more attention to and guide students in each stage of problem solving abilities, one of which is at the mathematical procedural stage.

CONCLUSION

The scientific process skills test instrument The average physics learning implementation on simple harmonic motion material is three times. Meetings using the POE2WE model are classified as effective in 78.9%, while meetings using the 5M scientific approach are classified as effective in 75.9%. Students' problem-solving ability has increased after applying the POE2WE model of 0.73, including the high category, and the 5M scientific approach of 0.62, including the medium category. The hypothesis test results show differences in problem-solving abilities between students using the POE2WE model with Phet Simulation and the 5M scientific approach with Amrita Olab Edu. As a result, this study can be cited in future research on the POE2WE model and used and implemented in schools that do not yet have laboratory equipment..

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