Berkala Ilmiah Pendidikan Fisika
https://ppjp.ulm.ac.id/journal/index.php/bipf
e-ISSN: 2549-2764 p-ISSN: 2337-604X
Vol 13 No 1 2025
DOI: 10.20527/bipf.v13i1.20092

Development of Physics Learning Media Integrated with Rebuttal Text (PhyLeM-ReT) on Work and Energy Material

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Article Info

Article history:
Received: July 29, 2024
Revised: October 31, 2024
Accepted: January 28, 2025

Keywords:
POEAW model
Rasch analysis
Rebuttal texts
Work and energy material

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Abstract

This study aimed to develop Physics Learning Media assisted by Rebuttal Texts (PhyLeM-ReT), integrated with the Predict, Observe, Explain, Apply, and Write (POEAW) model for work and energy material. The development research design employed in this study was ADDIE (Analysis, Design, Development, Implementation, and Evaluation). The participants were 30 tenth-grade students from a private high school in Bandung. A student response questionnaire to the media was implemented, which comprised 19 statements (10 positive and nine negative) and was evaluated using a Likert scale. This study implemented Rasch analysis. The result showed that 25 students agreed with the positive statements and disagreed with the negative statements related to interest in learning physics, the use of media, enthusiasm for learning, and usefulness in understanding concepts. Thus, PhyLeM-ReT integrated with the POEAW model facilitates students' comprehension of energy and work material. The developed media can also serve as an alternative for teachers in teaching, specifically enhancing and transforming students' conceptions. This research is crucial in an era where misconceptions regarding physics persist, as it aims to offer effective alternative learning media that can address these obstacles. Additionally, this research presents opportunities for further development in integrating comparable methods into other subject areas of physics that necessitate a profound conceptual approach.

To cite this article: Kurniasih, L., Samsudin, A., & Aminudin, A. (2024). Development of physics learning media integrated with rebuttal text (PhyLeM-ReT) on work and energy Material. *Berkala Ilmiah Pendidikan Fisika*, *13*(1), 1-11.

INTRODUCTION

Concept understanding is a fundamental skill students must possess after learning physics. In their research, Ozkan and Selcuk (2015), stated that concepts are very important in physics. However, students continue to encounter challenges in the physics learning process, particularly in the form of concepts that are not in alignment with scientific concepts (Aminudin et al., 2019; Adimayuda et al., 2020; Jubaedah et al., 2019; Putri et al., 2019). Understanding concepts that are not in accordance with scientific concepts is known as misconceptions. A misconception is a problem that is frequently addressed in order to facilitate further learning (Salmadhia et al., 2021). Teachers' lack of understanding regarding the precise causes of students' misconceptions is the cause of their inability to resolve the issue (Suparno, 2013).

Misconceptions are frequently encountered in various subjects within the field of physics education, including: 1) the concept of mechanics (Khaerunnisak, 2018; Maison et

al., 2020) 2) the concept of force and motion (Bayraktar, 2009; Liu & Fang, 2016; Narjaikaew, 2013; Poutot & Blandin, 2015; Saglam-Arslan, A. & Devecioglu, 2010); 3) the concept of geometric optics (Kaltakci-Gurel et al., 2017); 4) the concept of electricity and magnetism (Leppavirta, 2012; Peşman & Eryilmaz, 2010; Preston, 2019); and 4) the concept of fluid dynamics (Purwanto et al., 2018).

The field of mechanics is among the most prone to misconceptions within physics, particularly in work and energy (Maison et al., 2020). Work and energy are one of the most complex topics in mechanics (Purwati et al., 2019). The interconnectedness of numerous concepts is the source of their complexity (Khaerunnisak, 2018; Sudarmini et al., 2015)The essential materials in work and energy include work, energy (both kinetic and potential), the law of energy conservation, conservative and non-conservative forces, and power. In line with the preliminary study conducted in class X of one of the high schools in Bandung City, 42% of students experienced misconceptions about the materials of work and energy.

Misconceptions can originate from various factors, including teachers, textbooks, and other learning resources (Jauhariyah et al., 2018; Suprapto, 2020). Teachers are required to provide students with engaging and impactful learning experiences, as they are instrumental in influencing students' comprehension in the classroom. Teachers can leverage technological advancements by incorporating interactive learning media that students can access directly. The media must be integrated with the appropriate learning model and text to optimize transforming conceptions. One of them is the utilization of rebuttal text (Samsudin et al., 2021).

A rebuttal text is a text that refutes misconceptions (Samsudin et al., 2021). Research has demonstrated that rebuttal texts can assist students in grasping a concept more effectively (Caleon & Subramaniam, 2013; Kendeau & Broek, 2007; Nussbaum et al., 2017; Purwati et al., 2019).

This study combines rebuttal texts with a learning model to enhance understanding of physics concepts and align students' physics conceptions with scientific principles. This is achieved through the Predict, Observe, Explain, Apply, Write (POEAW) learning model (Samsudin et al., 2020). The POEAW model is a development of the Predict, Observe, Explain, and Apply (POEA) learning model and the Think, Talk, Write (TTW) strategy (Luthfiani et al., 2018).

The principles of learning with the POEAW model, according to Luthfiani et al. (2018), are: 1) Predict. In the early stages of learning activities, students are required to predict answers related to the available phenomena. 2) Observe. Students observe a demonstration or video or conduct exploration to answer existing problems. 3) Explain. After the observation process, students are asked to explain the results of the observations and compare the observations with the predictions made. 4) Apply. New concepts that have been learned are applied to solve problems in new phenomena. 5) Write. In the 1st to the fourth stages, students use the thinking process to learn new concepts. The final step in assimilating knowledge into the students' minds is to write their learning outcomes. At this stage, the teacher can provide a reflection sheet for students to fill out.

The POEAW model is based on three main stages: predicting the phenomenon that appears, observing the phenomenon, and comparing the prediction results with what is observed. It can assist students in grasping a concept more effectively and reshaping their existing conceptions (Berek et al., 2016; Coştu et al., 2012; Jasdilla et al., 2019; Samsudin et al., 2017).

This study developed the rebuttal text and the POEAW model into an interactive digital medium that students can easily access with an internet connection. This is intended to enhance the learning experience by making it more engaging, comprehensible, and engaging for students. Interactive media that captivate students' interest effectively corrects misconceptions, as indicated by numerous studies (Samsudin et al., 2017; Yilmaz et al., 2018). Digital media effectively makes abstract concepts more tangible, which helps

students better grasp the content presented in the text (Samsudin et al., 2021). Additionally, integrating simulations into the media empowers students to conduct hands-on investigations with control over variables, making learning more engaging and interactive (Jian-Hua & Hong, 2012). Thus, this study aims to develop Physics Learning Media based on Rebuttal Text integrated with the POEAW model to change students' conceptions of work and energy material, which is analyzed using Rasch analysis.

Rasch analysis is a statistical method that can accurately measure the interaction of respondents with instrument items, provide an overview of PhyLeM-ReT, and be interpreted in the social sciences as a psychometric tool (Brandt et al., 2015; Joyce & Yates, 2007; Lim et al., 2009; Planinic et al., 2019).

As evidenced by the current issues, interactive media is required to enhance students' conceptions and offer a more meaningful learning experience. Consequently, this research aims to create Physics Learning Media assisted by Rebuttal Texts (PhyLeM-ReT) integrated with the Predict, Observe, Explain, Apply, and Write (POEAW) model. This model is specifically designed to alter students' conceptions of work and energy material.

METHODS

This research is development research using ADDIE design (Analysis, Design, Development, Implementation and Evaluation) (Richey et al., 2004). A needs analysis was conducted with grade X students regarding media needs in the learning process. Next, the design stage involves the development of a rebuttal text that is incorporated into the POEAW model, as well as creating a questionnaire instrument to evaluate the feasibility of the media that has been created. The Articulate Storyline application was validated by experts and was employed to generate media during the development phase. Evaluation and enhancement are implemented at each stage to ensure the media developed is suitable for its intended purpose.

The participants in this study consisted of 30 students (15 female and 15 male) of class X in one of the private high schools in Bandung City. The students have acquired the material of work and energy, but based on the preliminary study, they are classified as having high misconceptions.

The instrument employed was a questionnaire comprising 19 statements, 10 positive and nine negative, using a Likert scale of Strongly Agree (SS), Agree (S), Disagree (TS), and Strongly Disagree (STS). This tool was utilized to gauge student responses after learning with PhyLeM-ReT. The instrument is detailed in Table 1 and encompasses four assessment aspects.

Table 1 showed that the indicators of student responses consisted of four aspects: interest in learning physics, interest in using the media, passion for learning, and usefulness in understanding the concept. Out of the 19 statements in Table 1, 10 are positive, namely P1, P2, P4, P7, P9, P11, P13, P15, P17, and P18. The remaining nine statements are negative, including P3, P5, P6, P8, P10, P12, P14, P16, and P19.

Table 1 Indicators of student response statements

Aspect	Code	Statement
Interest in learning physics	P1	I am more interested in physics when learning using PhyLeM-ReT integrated with the POEAW model.
	P2	I find it easier to apply physics knowledge to daily life while studying using PhyLeM-ReT integrated with the POEAW model.
	P3	I became confused about using physics principles in everyday situations while learning using PhyLeM-ReT integrated with the POEAW model.
Interest in using the media	P4	I am enthusiastic about physics learning when it is taught through engaging media.
	P5	I am not enthusiastic about physics learning when it is taught through engaging media.

Aspect	Code	Statement
	P6	PhyLem-ReT makes me sleepy when learning about work and energy.
	P7	Learning work and energy with PhyLeM-ReT makes the content simple to recall.
	P8	PhyLeM-ReT makes it difficult for me to learn about energy and work.
	P9	I like learning about energy and work with videos and simulations.
	P10	I am not interested in learning about work and energy with videos and simulations.
	P11	I really enjoyed learning about work and energy using the POEAW model.
Passion for learning	P12	Learning with the POEAW model is very boring.
	P13	The POEAW model makes me understand the material of work and energy.
Usefulness to understand the concept	P14	The POEAW model makes it difficult for me to learn about energy and work.
	P15	PhyLeM-ReT integrated with the POEAW model is more useful for learning work and energy.
	P16	When learning to use PhyLeM-ReT, which is integrated with the POEAW model, I don't understand the material of work and energy.
	P17	I realized my lack of understanding of energy and work after reading the text in the scientific explanation.
	P18	I became more active when learning using PhyLeM-ReT integrated with the POEAW model.
	P19	I do not understand the meaning of the text in PhyLeM-ReT

RESULTS AND DISCUSSION

The results are presented following the ADDIE design.

Analysis

This stage includes collecting information about the needs for learning, the goals for learning, and the characteristics of the students. The need analysis phase was carried out at a Bandung private high school. Brief interviews were conducted with numerous students and physics teachers to acquire the necessary information. It was discovered during these interviews that students' primary method of participation in educational activities was through the teacher's PowerPoint presentations. In addition to the interviews, a diagnostic test was administered to students to evaluate their comprehension of the work and energy material. The results indicated that 42% of the students had misconceptions. Consequently, interactive media is required to improve student engagement in learning and deepen their comprehension of physics concepts (Jian-Hua & Hong, 2012).

Design

Rebuttal text consists of three components: presentation of common misconceptions, rebuttal sentences, and scientific explanations. The three components were integrated into the POEAW learning model, which has five learning stages. In this design stage, a storyboard was created, as shown in Figure 1.

The media displays phenomena related to work and energy in the initial activity. Students were asked to predict the answer to the problem presented based on their understanding of the concept. Furthermore, students read rebuttal texts that demonstrate that common misconceptions are not in accordance with scientific concepts and that these misconceptions are unfounded. Consequently, students experienced cognitive conflict. Additionally, students conducted observations through simulations and recordings and compared the outcomes to their initial predictions during the explained stage. Subsequently, scientific explanations were implemented. The employ stage involves the

application of scientific concepts that students have already acquired to address novel problems. At the end of learning, students completed a reflection sheet at the writing stage.

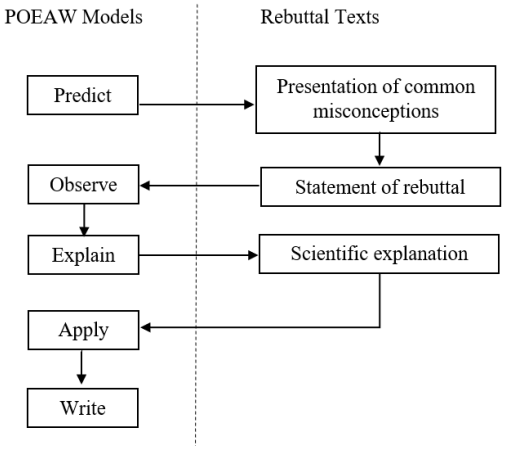

Figure 1 Storyboard of rebuttal texts integrated with the POEAW model

Develop

PhyLeM-ReT integrated with the POEAW model was developed using the Articulate Storyline application, as shown in Figure 2.

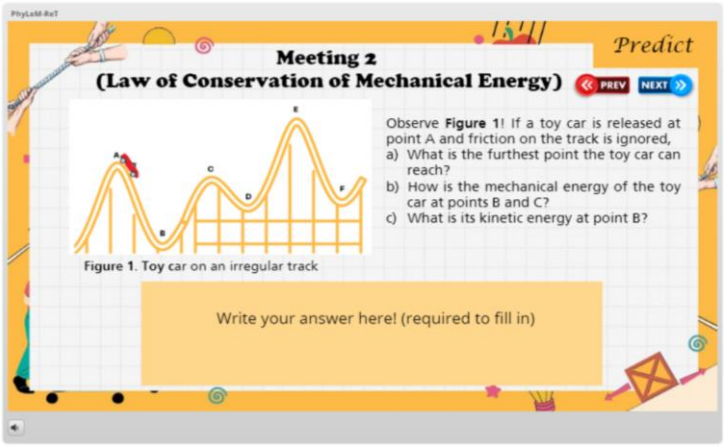

Figure 2 Example of PhyLeM-ReT display

Phy-LeM-ReT can be operated using a computer, laptop, or smartphone connected to the internet. Subsequently, a panel of four experts, including lecturers and teachers, conducted a validation process on the media. The validation results were processed using Facet software, as shown in Figure 3.

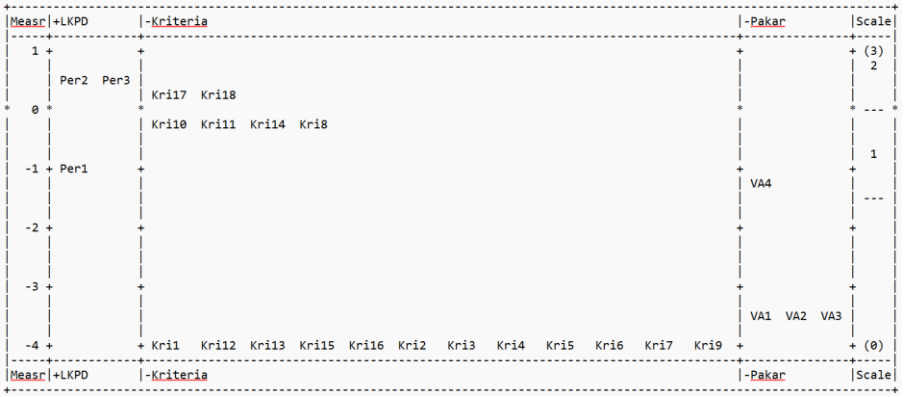

Figure 3 Distribution of media validation by experts

Figure 3 shows 19 assessment indicators, including aspects of media suitability with the POEAW model, correctness and depth of concepts, language, layout, navigation buttons, and media facilities. The validation results obtained raw variance explained by measures 41.18%, meaning that it is included in the appropriate category based on the uni-dimensional test criteria according to Sumintono and Widhiarso (2015). Thus, PhyLeM-ReT is feasible, but it necessitates enhancement in accordance with the validator's recommendations.

Implementation

Students evaluated the mediation of enhancement implementation. Students, at the inclusion of the lesson to ASCE, completed a questionnaire to record their responses to the integration of PhyLeM-ReT with the POEAW model.

Evaluation

The results of student responses were processed using the MiniStep application and Rasch analysis, as shown in Figure 4.

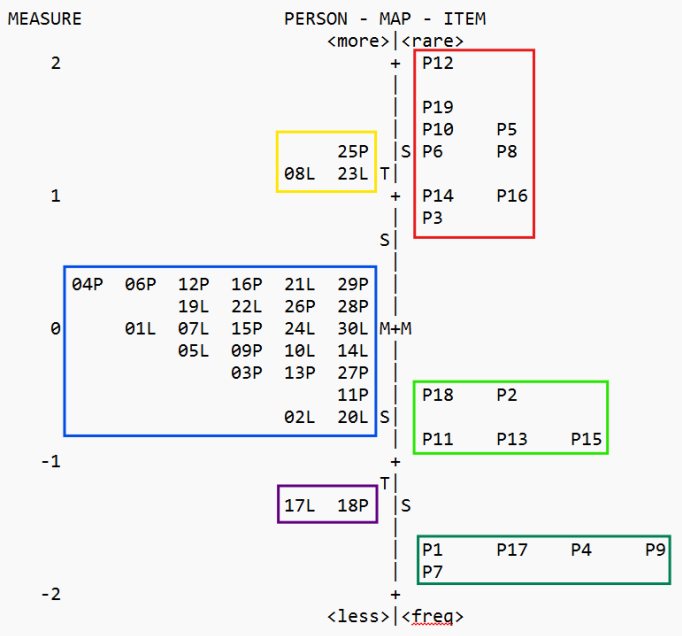

Figure 4 Distribution of students' responses

Figure 4 shows that the distribution of students with their gender and serial number coded is on the left, and the distribution of student replies is on the right (P1-P19), consisting of positive and negative statements. The red boxes (P3, P5, P6, P8, P10, P12, P14, P16, P19) are negative statements. The nine negative statements cover four categories: interest in learning physics, use of media, enthusiasm for learning, and usefulness in understanding work and energy concepts. Students with codes 17L and 18P responded "Disagree" to all statements. Meanwhile, students coded 08L, 23L, and 25P responded "Agree" to all statements. It is conceivable that these students are incorrect in their interpretation of the statements, as they are both positive and negative.

However, most students in the blue box agreed with the positive statements and rejected the negative statements. This study's results suggest that students can apply physics concepts to their daily lives and are enthusiastic about the learning process, facilitating their comprehension of work and energy material. Therefore, Physics Learning Media based on Rebuttal Text (PhyLeM-ReT) integrated with the POEAW model can change students'

conceptions of work and energy material in accordance with scientific concepts. Next, the instruments used have high-reliability values, as shown in Figure 5.

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	47.9	19.0	.00	.36	.97	-.10	.99	-.02
SEM	.8	.0	.11	.00	.06	.18	.06	.18
P.SD	4.6	.0	.59	.01	.31	.99	.30	.95
S.SD	4.6	.0	.60	.01	.32	1.01	.31	.97
MAX.	58.0	19.0	1.33	.38	1.86	2.33	1.82	2.24
MIN.	38.0	19.0	-1.28	.35	.47	-2.13	.54	-1.78

REAL RMSE	.38 TRUE SD	.45	SEPARATION 1.19	PERSON RELIABILITY	.58
MODEL RMSE	.36 TRUE SD	.46	SEPARATION 1.29	PERSON RELIABILITY	.63
S.E. OF PERSON MEAN = .11					

PERSON RAW SCORE-TO-MEASURE CORRELATION = 1.00

CRONBACH ALPHA (KR-20) PERSON RAW SCORE "TEST" RELIABILITY = .61 SEM = 2.85

STANDARDIZED (50 ITEM) RELIABILITY = .82

SUMMARY OF 19 MEASURED ITEM

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	75.6	30.0	.00	.29	.99	-.17	.99	-.15
SEM	4.1	.0	.32	.00	.09	.39	.09	.39
P.SD	17.3	.0	1.34	.01	.39	1.64	.39	1.66
S.SD	17.8	.0	1.38	.02	.40	1.69	.40	1.71
MAX.	98.0	30.0	1.97	.31	1.88	2.88	1.85	2.85
MIN.	50.0	30.0	-1.81	.27	.36	-3.21	.36	-3.21

REAL RMSE	.31 TRUE SD	1.31	SEPARATION 4.24	ITEM RELIABILITY	.95
MODEL RMSE	.29 TRUE SD	1.31	SEPARATION 4.58	ITEM RELIABILITY	.95
S.E. OF ITEM MEAN = .32					

Figure 5 Summary statistics from student's responses

Figure 5. shows that the orange box indicates a person reliability value of 0.58, categorized as "weak," while the purple box denotes an item reliability value of 0.95, which falls under the "very good" category (Sumintono & Widhiarso, 2015). This suggests that student responses to the questionnaire are inconsistent, although the instrument's quality is considered excellent. The blue box emphasizes the interaction between person and item reliability, categorized as "sufficient" with a Cronbach's alpha of 0.61. The green box displays the person separation value, while the yellow box indicates the item separation value of 1.19 and 4.24, respectively. To gain a comprehensive understanding of their implications, it is necessary to calculate these values using Equation 1.

$$H=[(4\times separation)+1]/3 \quad (1)$$

The stratum value is denoted by the H value in Equation 1. The separation value of 1.19 for the person stratum results in a value of 1.92, which is classified as "sufficient" (Sumintono & Widhiarso, 2015). This implies that the students are divided into two categories when rounded up. Conversely, the item stratum is classified as "extraordinary" due to its separation value of 4.24, which yields a value of 5.98 (Sumintono & Widhiarso, 2015). The instrument's high quality for data collection is suggested because it comprises six groups when rounded up.

Further analysis is necessary to support the research findings and use instruments such as student response questionnaires regarding the use of PhyLeM-ReT in learning. One method is to employ observation sheets to evaluate the application of knowledge in accordance with the POEAW model.

CONCLUSION

Learning media developed in this study for physics learning, integrated with the Predict, Observe, Explain, Apply, and Write (POEAW) model and rebuttal texts, can help students rethink their concepts about work and energy. The instrument used to measure students' responses to PhyLeM-ReT is considered a good-quality instrument for collecting data based on Rasch analysis. Additionally, the majority of students endorsed the positive statements and denied the negative statements presented in the response questionnaire.

This study is limited to using student response questionnaires as the primary instrument for measuring the effectiveness of the media. While this study provides insight into student perceptions, the use of other instruments, such as cognitive tests or direct observation, has the potential to generate more comprehensive data.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, LK and AS; methodology, LK, AS and AM; formal analysis, LK writing—preparation of the original draft, LK.

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