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DEVELOPMENT OF NON-COGNITIVE INSTRUMENT FOR STUDENT MOTIVATION IN WORK-ENERGY USING PBL MODEL

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Abstract :
This study aimed to develop a non-standardized, context-appropriate instrument to measure student motivation to learn about work and energy within a problem-based learning (PBL) framework. The development of this instrument addresses the lack of valid and reliable tools for physics learning by providing a means of assessing motivation in active, problem-solving classrooms. A research and development (R&D) approach was employed, and the construct validity of the instrument was examined using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The study included 150 students who had previously participated in PBL-based physics learning. The results showed that the instrument demonstrated high reliability (Cronbach's alpha = 0.95) and was suitable for factor analysis (KMO = 0.83, Bartlett's test = 0.000). Exploratory factor analysis (EFA) revealed two main factors explaining 53% of the total variance, and confirmatory factor analysis (CFA) validated a two-factor model with moderate fit (CFI = 0.797; TLI = 0.772; RMSEA = 0.129; SRMR = 0.074). These results demonstrate the feasibility and effectiveness of the instrument for measuring student motivation in problem-based physics learning. Its originality lies in its contextual design, which allows for the capture of motivation related to physical content, problem-solving, and collaboration, unlike general motivation scales. This study offers an empirically validated tool for more precise assessment, the improvement of teaching practices, and future research, although further refinements are still needed.

Keywords: Work and Energy, Motivation to Learn, Non-Test Instruments

INTRODUCTION

Learning physics requires students to understand abstract concepts and develop sound reasoning. Motivation is a key psychological factor that helps them overcome the challenges they encounter in physics, particularly those related to work and energy. Strong motivation enables them to actively engage, persevere, and demonstrate an interest in solving complex problems. Therefore, it is essential to have a tool that accurately measures motivation and is tailored to the context of physics learning. Modern physics education also requires teaching models that foster the development of critical thinking. Problem-based learning (PBL) is one such model, it encourages active student engagement and strengthens their motivation. By focusing on solving contextualized problems, PBL promotes critical thinking, knowledge building, and collaborative learning. To assess the effectiveness of PBL in motivating students, a measurement tool specifically designed for this learning process is needed (Arrieta-Cohen et al., 2024).

Most of the motivational tools used in previous studies are generic and not tailored to physics learning. These tools often fail to capture contextual aspects of motivation, such as interest in experiments, understanding of energy concepts, or the willingness to solve complex physics problems from both mathematical and conceptual perspectives. Studies have shown that generic tools frequently overlook domain-specific characteristics, highlighting the need for tools that are both context-sensitive and physics-specific (Ruslan & Mustapa, 2023). Furthermore, psychometric instruments must guarantee their validity and reliability for dependable measurement. Construct validity is crucial because without it, results cannot reliably inform educational decisions. Many existing instruments rely on theoretical assumptions without adequate empirical validation, raising questions about their reliability and validity (Duryadi, 2024).

Non-experimental instruments for measuring motivation in physics learning remain scarce. Some studies simply adapt existing instruments without re-examining their factor structure, even though students' motivational profiles can vary depending on the learning model, the complexity of the content, and their individual characteristics. The "Work and Energy" theme, which combines mathematical calculations with in-depth conceptual understanding, offers a unique learning context likely to elicit motivational patterns distinct from those observed in other physics themes (Lara-bercial et al., 2024).

Problem-based learning (PBL) inherently requires active student participation in problem-solving, which can strengthen dimensions of motivation such as self-efficacy, curiosity, and the desire to master concepts. However, understanding its impact on motivation requires tools specifically designed for these dimensions within the context of physics learning. The lack of such tools limits the ability of researchers and teachers to effectively assess PBL. Existing motivation measurement instruments have rarely been tested by exploratory or confirmatory factor analysis, yet factor analysis is essential to ensure that items accurately measure the targeted concepts and reflect the true motivational structure, based on empirical data rather than theory alone (Lavado-anguera, 2024).

To address these shortcomings, this study develops an innovative, contextual, and non-test-based instrument to measure students' motivation to learn the concepts of work and energy within the framework of problem-based learning (PBL). Grounded in motivation theory and adapted to the characteristics of physics learning, the instrument has undergone rigorous empirical validation using modern statistical methods. This study fills the gap in the existing physics-specific, empirically validated tool for measuring motivation. Beyond creating a new instrument, it provides an empirical basis for understanding the structure of motivation in PBL-based physics courses. The resulting tool should help teachers, researchers, and practitioners to accurately assess student motivation, guide pedagogical improvements, and inform future research (Choi, 2025).

The originality of this study lies in the development of a contextualized motivational instrument that explicitly integrates the characteristics of problem-based learning (PBL) and the conceptual requirements of physics, particularly with regard to work and energy. Unlike previous instruments that adopt a general approach, this study emphasizes the alignment between motivational factors and domain-specific learning activities, such as problem-solving, conceptual reasoning, and collaborative research in physics. Furthermore, the instrument is not simply adapted but has been systematically developed and empirically validated through rigorous factor analysis to ensure its construct validity and reliability. This approach provides a more accurate representation of students' motivational profiles in PBL-based physics learning environments and makes a significant contribution to addressing the limited availability of validated, discipline-specific motivational measures.

The objective of this study is therefore to develop and empirically validate an instrument for measuring student motivation within the framework of problem-based physics (PBL), specifically on the topic of work and energy. This study aims to examine the construct validity and reliability of the instrument through exploratory and confirmatory factor analyses, in order to ensure that each item accurately reflects the targeted motivational dimensions. In doing so, the study seeks to provide a robust and context-appropriate measurement tool for evaluating and improving the effectiveness of PBL in physics education.

RESEARCH METHODS

This study employed a research and development (R&D) methodology to design and validate a non-test instrument for measuring student motivation in physics, specifically within the context of problem-based learning (PBL) on the topic of work and energy. The R&D approach was chosen because it allows for a systematic process of constructing, evaluating, and improving the instrument, thus ensuring its theoretical relevance and empirical validity. The development procedure followed a structured model for instrument development, adapted from recognized educational research frameworks (Manzano-le et al., 2021). The process included several key steps:

1. identification of concepts and development of the theoretical framework, where the indicators of motivation for learning were derived from the theories of intrinsic and extrinsic motivation;
2. instrument design, including the preparation of a plan (grid) and the drafting of elements;
3. validation by experts, involving specialists in the field and measurement experts to assess the validity of the content and the clarity of the elements;
4. pilot test (field trial), conducted with students to collect empirical data; and
5. psychometric analysis, including validity and reliability tests using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

This design prioritizes an iterative process, where the results of each step allow for revisions and improvements to the instrument. Through this systematic approach, the study ensures that the developed questionnaire is not only based on solid theoretical foundations but is also empirically validated, thus meeting the need for a valid and reliable instrument to measure students' motivation to learn physics through problem-based learning.

Research design

This research was conducted during the even semester of the 2024/2025 academic year at SMA Negeri 1 Plosoklaten High School. The research location was chosen based on participant availability and school support. This study used a research and development (R&D) approach, adapted from Borg and Gall, to design a non-testable instrument measuring student motivation in physics, specifically within the context of problem-based learning (PBL) on work and energy. PBL emphasizes student-centered problem-solving, collaboration, and reflection, and contributes to shaping both intrinsic (curiosity, perseverance) and extrinsic (grades, teacher expectations) motivation. The instrument items were designed to reflect students' experiences in PBL activities (Manzano-le et al., 2021).

The development followed a simplified five-step Borg and Gall model:

1. Needs analysis and literature review: identification of motivational factors and characteristics of problem-based learning, resulting in a conceptual framework.
2. Instrument planning and design: Creation of an instrument plan and 20 Likert scale items covering intrinsic and extrinsic motivation.
3. Validation by experts: Evaluation by experts in physics education and metrology to ensure the validity and clarity of the content, followed by revisions.
4. Field tests: Administration to students experienced in problem-based learning in order to collect empirical data.
5. Data analysis and refinement: Exploratory and confirmatory factor analysis assessed construct validity, and Cronbach's alpha assessed reliability, leading to the final refinement of the instrument.

This iterative process has made it possible to produce a theoretically grounded and empirically validated instrument, offering a context-appropriate tool for assessing learning motivation in problem-based physics teaching.

Target/Research Topic

The study involved 150 students from SMA Negeri 1 Plosoklaten High School who participated in the instrument's pilot testing. Participants were selected using purposive sampling based on specific criteria related to the study's objectives: (1) having studied the theme "Work and Energy," (2) having experienced problem-based learning (PBL), and (3) actively participating in classroom learning activities. This approach ensured that the selected sample was appropriate for evaluating the learning motivation measurement instrument developed within its intended context. The sample size (150 respondents) was deemed sufficient for factor analysis. In exploratory factor analysis (EFA), it is generally recommended to have a minimum of 5 to 10 respondents per item. Since the instrument comprised 20 items, the required sample size was between 100 and 200 respondents, indicating that the sample used in this study met the recommended criteria. Furthermore, for confirmatory factor analysis (CFA), samples of more than 100 participants are generally considered adequate for obtaining stable parameter estimates, particularly in initial instrument development studies. Therefore, the sampling procedure and sample size of this study were deemed sufficient to allow for both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), thus ensuring that reliability and validity tests of the developed instrument could be conducted with adequate statistical power and methodological rigor (Thompson, 20201).

Search procedures

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Figure 1. Search procedures (Zainil et al., 2025)

This figure illustrates the systematic process of developing a non-test instrument to measure student learning motivation. This process begins with the design of an instrument plan based on motivation indicators, followed by the construction of items using a Likert scale. The instrument is then validated by experts to ensure the relevance of its content and language. After testing with students, the data are analyzed using exploratory factor analysis (EFA) to identify the factor structure and confirmatory factor analysis (CFA) to test the model's fit. A reliability analysis is conducted to assess internal consistency. Finally, the instrument is refined and finalized based on the results of the validity and reliability tests, thus ensuring its use in problem-based learning (PBL) physics contexts.

Data collection instruments and techniques

The research instrument used in this study was a learning motivation questionnaire consisting of 20 statements measured using a four-point Likert scale, ranging from "strongly disagree" (1) to "strongly agree" (4). The questionnaire was administered directly to students to collect data on their motivation to learn physics, specifically on the topic of work and energy within the framework of problem-based learning (PBL). To ensure content validity and clarity in the measurement of constructs, the instrument was developed using a structured design (instrument grid). The instrument measures two main dimensions of learning motivation: intrinsic and extrinsic motivation, each operationalized into several indicators (Komariah & Anwar, 2025).

Table 1. Instrument diagram and examples of components

Dimension	Indicator	Item number	Example of a declaration
Intrinsic motivation	Interest in learning physics	1	I am interested in learning physics, and more specifically in the topics of work and energy.
		2	I enjoy participating in physics learning activities.
		3	Physics is one of the subjects I really like.
	Curiosity about the concepts	4	I want to learn more about the physics concepts covered in class.
		5	I am looking for additional information on topics related to work and energy.
		6	I ask questions when I don't understand the physical subject matter.
	Perseverance in problem-solving	7	I keep trying even when the physics problems are difficult.
		8	I don't give up easily when faced with physics problems.
		9	I am motivated to accomplish complex physics tasks.
	The joy of learning	10	I find joy in learning physics through problem-solving activities.
		11	I enjoy discussing physics problems with my classmates.
Extrinsic motivation	Results (grades)	12	I'm studying physics to get good grades.
		13	Getting good grades in physics is important to me.
		14	I am motivated to learn physics in order to succeed in my studies.
	Recognition/rewards	15	I feel motivated when I receive compliments for my results in physics.
		16	The rewards from my teachers encourage me to learn physics better.
	Teacher Influence	17	My teacher motivates me to actively participate in learning physics.
		18	I am making an effort to study well because of my teacher's expectations.
	External pressure	19	I am studying physics because of upcoming tests or exams.
		20	Homework and deadlines motivate me to learn physics.

Table 1 presents the diagram of the developed instrument, detailing the dimensions, indicators, item distribution, and sample statements used to measure students' learning motivation. The instrument is structured around two main dimensions: intrinsic motivation and extrinsic motivation, each represented by several relevant indicators. Intrinsic motivation includes interest, curiosity, perseverance, and enjoyment of learning physics, while extrinsic motivation encompasses achievement, recognition, teacher influence, and external pressure. Each indicator is operationalized into specific items to ensure comprehensive measurement. This diagram demonstrates that the instrument is systematically designed to capture internal and external motivators within the context of problem-based physics (PBL) learning on work and energy.

Data analysis techniques

The data analysis was performed using the R software and the psych and lavaan packages. The analysis includes:

1. Data feasibility test using the Kaiser-Meyer-Olkin (KMO) and Bartlett sphericity tests.
2. Exploratory factor analysis (EFA) with the maximum likelihood method and oblimin rotation, to identify the factor structure of the instrument.
3. Confirmatory factor analysis (CFA) to test the relevance of the two-factor model obtained.
4. Internal reliability test using Cronbach's alpha coefficient.

The feasibility criteria for the instrument include a KMO value > 0.5, a significant Bartlett test, factor loading ≥ 0.40 and reliability ≥ 0.70. The feasibility of the confirmatory factor analysis (CFA) model is assessed on the basis of CFI and TLI values ≥ 0.80 (sufficient category), RMSEA ≤ 0.08 and SRMR ≤ 0.08, considered as indicators of a good fit of the model.(Castillo-reche, 2023).

RESULTS AND DISCUSSION

The results of this study present a series of statistical analyses carried out to test the feasibility of non-test-related instruments to assess students' motivation to learn the subject "Commerce and Energy" using the problem-based learning (PBL) model.(Saputri et al., 2025)The analysis included reliability tests, data feasibility tests, exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and interpretation of the resulting factor structure. All analyses were performed on 150 respondents using 20 statements on a Likert scale.(Hashim, 2023).

1. Instrument reliability test

The internal reliability of the instrument was tested using Cronbach's alpha coefficient. The results showed an α value of 0.95, indicating very high reliability. Removing each item produced α values between 0.94 and 0.95, indicating that no item decreased the reliability of the instrument.

Table 2. Results of Cronbach's alpha reliability test

Statistics	Brand
Number of items	20
Cronbach's alpha (raw)	0.95
Cronbach's alpha (standard deviation)	0.95
Average correlation between items	0.47
Signal-to-noise ratio	18

Table 1 shows that the learning motivation measurement instrument exhibits very high reliability, as indicated by a Cronbach's alpha (raw and standardized) of 0.95, well above the minimum threshold of 0.70 required for a reliable instrument. Composed of 20 items and exhibiting an average inter-item correlation of 0.47, it is clear that each item is strongly correlated with the others, thus consistently measuring the same construct (Yugakisha et al., 2021)The signal-to-noise ratio (S/N) of 18 also indicates that the variance generated by the instrument stems primarily from the measured signal or construct, rather than from errors. Overall, these results confirm that the developed instrument is highly stable and reliable for assessing students' motivation to learn (Lim et al., 2022).

2. Data feasibility testing (KMO and Bartlett tests)

To determine if the data is suitable for factor analysis, the KMO test and Bartlett's test are performed.

Table 3. Results of the KMO and Bartlett tests

Test	Results
KMO Global	0.83
Bartlett's test – Chi-squared	2,151,991
df	190
Sig. (value p)	0.000

Table 2 shows that the instrument meets the eligibility criteria for factor analysis. The KMO value of 0.83 is excellent, meaning that the inter-item correlation is very strong and that the data structure is ideally suited for factor formation (Sanchez & Porro, 2024)Furthermore, the results of Bartlett's test, with a χ^2 value of 2,151.991 and a significance level of 0.000, indicate that the correlation matrix is not an identity matrix, suggesting the existence of a significant relationship between the variables. The combination of these two results confirms that the data are suitable for exploratory factor analysis (EFA) to identify the factor structure underlying the learning motivation measurement instrument (Stoyanova, 2023).

3. Exploratory Factor Analysis (EFA)

Parallel analysis reveals the presence of two factors. The estimation method used is maximum likelihood with oblimin rotation. These two factors explain 53% of the total variance.

Table 4. Results of factor analysis (AFE, 2 factors)

Article	Factor 1 (ML2)	Factor 2 (ML1)	h^2
Article 1	0.90	0.11	0.92
Article 2	0.79	-0.07	0.57
Article 3	0.59	0.03	0.36
Article 4	0.39	0.50	0.61
Article 5	0.68	-0.10	0.40
Article 6	0.65	0.08	0.49
Article 7	0.54	0.02	0.30
Article 8	0.78	-0.15	0.51
Article 9	0.01	0.98	0.98
Article 10	0.82	-0.07	0.61
Article 11	0.70	-0.19	0.38
Article 12	0.60	0.18	0.51
Article 13	0.62	0.09	0.45
Article 14	0.71	-0.04	0.48
Article 15	0.61	0.15	0.49
Article 16	0.60	0.15	0.47
Article 17	0.71	0.00	0.50
Article 18	0.29	0.35	0.32
Article 19	0.76	0.00	0.58
Article 20	0.68	0.19	0.63

Table 3 presents the results of the exploratory factor analysis (EFA) with two main factors. Factor 1 (ML2) is dominated by items with high loadings, such as items 1 (0.90), 2 (0.79), 8 (0.78), and 10 (0.82), indicating that it represents students' intrinsic motivation for learning physics. Factor 2 (ML1), on the other hand, has the highest loadings for items 9 (0.98) and 4 (0.50), suggesting that it is related to extrinsic motivation, such as value-ladenness or external demands. The high h^2 (community) values for items 1 (0.92) and 9 (0.98) indicate that these two items explain the variance of the motivation construct very well. Conversely, some items, such as items 7 and 18, have a relatively low h^2, indicating that their contribution to the motivation construct is less than that of other items (Bogner, 2022)Overall, this table confirms the existence of two distinct but complementary dimensions of learning motivation in the developed instrument. These results also indicate that most items fall within the appropriate factors, consistent with the underlying theoretical concepts. The resulting two-factor structure strengthens the instrument's construct validity, as the loading profiles consistently follow the characteristics of intrinsic and extrinsic motivation. Thus, the results of the exploratory factor analysis (EFA) provide a solid empirical basis for conducting confirmatory factor analysis (CFA) to further test the model's relevance (Berlin, 2021).

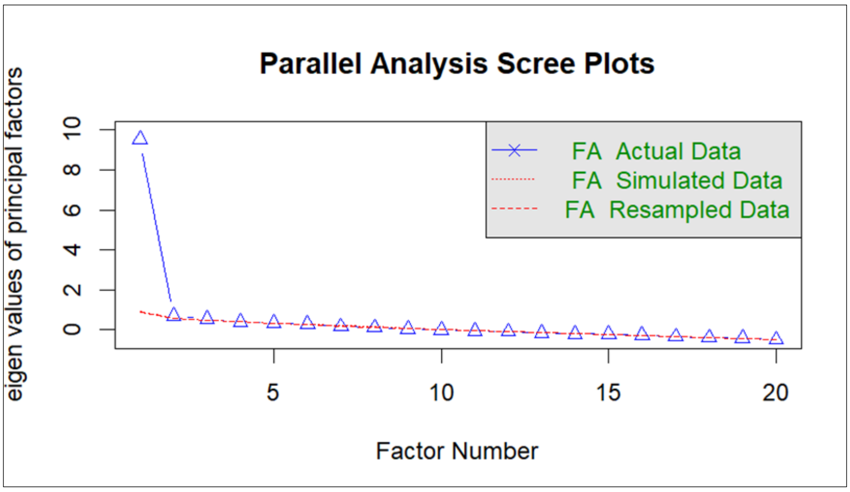

Figure 2. Rockfall diagram from parallel analysis

The figure presents a parallel analysis scree plot, used to determine the optimal number of factors in exploratory factor analysis (EFA). On this plot, the blue line represents the eigenvalues of the real data, while the red dashed and solid lines represent the eigenvalues of the simulated and resampled data.(Mahendra, 2024)The principle of interpretation is that a factor is retained only if the eigenvalue of the actual data is greater than that of the simulated data. The graph shows that only the first two points of the blue line lie above the simulated line; therefore, we can conclude that the data structure is best represented by two factors. This figure confirms the analysis that the learning motivation measurement instrument exhibits a significant two-factor structure.(Teppo & Soobard, 2021).

4. Confirmatory Factor Analysis (CFA)

The two-factor EFA model was retested using confirmatory factor analysis (CFA) to ensure model fit.

Table 5. CFA Adequacy Index

Hint	Brand	Criteria
CFI	0.797	≥ 0.90 (good)
TLI	0.772	≥ 0.90 (good)
RMSEA	0.129	≤ 0.08 (good)
SRMR	0.074	≤ 0.08 (good)

Table 4 shows that the goodness-of-fit test results for the model derived from the confirmatory factor analysis (CFA) fall within the marginal goodness-of-fit category. The CFI (0.797) and TLI (0.772) values are below the optimal threshold of 0.90, indicating that the two-factor model does not optimally describe the data. However, the SRMR value (0.074) meets the goodness-of-fit criteria, indicating that the difference between the model's covariance matrix and the actual data is relatively small.(Juhairiyah, 2024)Conversely, the RMSEA value of 0.129 is above the ideal limit of ≤ 0.08, indicating that the model still requires structural improvements. Overall, these results show that, while the model is not a perfect fit, it remains acceptable as a preliminary model and can be improved through item revisions or model adjustments in future research.(Ren and Wang, 2025).

5. Breakdown of the ideal score and the total score

The student's total score is converted into an ideal Z-score in order to observe the distribution of trends in learning motivation.

Table 6. Statistics of total student scores

Statistics	Brand
Average total score (observation)	74.2
Ideal score (Mid-total)	50
Ideal standard deviation (Si_total)	2,236

Statistics	Brand
Beach Z	5.36 – 13.41
Interpretation	Most students achieve a grade higher than the ideal grade (strong motivation).

Table 5 shows that the students' total mean observation score (74.2) is significantly higher than the ideal score (Mi_total) of 50, indicating a generally high level of motivation to learn. The ideal standard deviation (Si_total) of 2.236 indicates a relatively stable distribution of scores, while the range of Z-values (from 5.36 to 13.41) confirms that almost all students achieved scores above the ideal value (Gabriel et al., 2024)The overall interpretation of these statistics shows that students demonstrate a strong motivation for learning the work and energy curriculum, which is probably due to the implementation of the problem-based learning (PBL) model, likely to increase their engagement and interest in learning (Sarbaitinil et al., 2024).

This study fills a significant gap in physics education research, namely the lack of non-standardized, psychometrically validated, and context-appropriate measurement instruments designed to assess student motivation in problem-based learning (PBL), particularly in the context of work and energy. Previous studies have generally examined student motivation using generic instruments that are not specific to the physics content or the characteristics of PBL. The originality of this study therefore lies in the development of a contextualized, PBL-oriented motivation measurement instrument that integrates both domain-specific content (work and energy) and the pedagogical approach (PBL), thus providing a more precise and relevant measurement tool for classroom use.

The results of the reliability analysis indicate that the developed instrument exhibits very high internal consistency. A Cronbach's alpha coefficient of 0.95 demonstrates that the relationships between the items are excellent (Macintosh & Asghar, 2025). This suggests that students responded consistently to the different questions, indicating that the instrument reliably measures the concept of motivation to learn. This result is consistent with psychometric norms, which consider alpha values greater than 0.90 as indicative of high-quality instruments, and reinforces previous research highlighting the importance of reliability in educational measurement (Alvarez & Greca, 2025). Thus, this study effectively addresses the identified research gap by proposing a highly reliable and context-appropriate instrument. Furthermore, the feasibility analysis, conducted using KMO and Bartlett's tests, confirms the relevance of factor analysis. The satisfactory KMO value of 0.83 indicates sufficient inter-item correlations, while the significant result of Bartlett's test confirms that the correlation matrix is suitable for factor extraction (Putri et al., 2023).

These results reinforce the methodological rigor of the study and demonstrate that the instrument's structure is empirically grounded, thus addressing the need for validated measurement tools highlighted by the lack of research. Exploratory factor analysis (EFA) revealed two main factors: intrinsic motivation and extrinsic motivation, which together explain 53% of the total variance. This structure is consistent with classical and contemporary theories of motivation (Mutanga, 2024). Confirming that the developed instrument captures the essential dimensions of student motivation, the emergence of these two factors in a problem-based learning context reinforces the novelty of the study: it shows that even in student-centered and inquiry-based environments, intrinsic and extrinsic motivations remain relevant and measurable concepts. The intrinsic motivation factor demonstrated high loadings on items related to interest, curiosity, and perseverance, particularly on items 1, 8, and 10 (Andri, 2026). This suggests that problem-based learning (PBL) effectively fosters intrinsic motivation by encouraging active engagement and independent problem-solving. These findings support previous studies indicating that PBL environments can stimulate curiosity and deeper cognitive involvement (Marcinauskas et al., 2024).

This study directly addresses the lack of research on how motivation manifests in problem-based physics learning by providing empirical evidence for the significant role of intrinsic motivation. Furthermore, the extrinsic motivation factor was strongly represented by items such as item 9 and item 4, which exhibited high factor loadings (Zagulova et al., 2025). This indicates that external influences, such as grades and teacher expectations, continue to shape student motivation, even within problem-based learning (PBL). This finding highlights an important point: while PBL fosters autonomy and intrinsic engagement, extrinsic factors remain influential. This nuanced understanding enriches the literature by demonstrating that motivation in PBL contexts is not purely intrinsic, thus expanding on previous hypotheses and strengthening the study's contribution. A confirmatory factor analysis (CFA) was performed to validate the two-factor model obtained through exploratory factor analysis (EFA) (Dog, 2025). The results indicated that, although the CFI and TLI values did not fully reach the ideal thresholds, the SRMR value was within an acceptable range, suggesting a moderate adjustment of the model. This result is common in the early stages of instrument development, where iterative refinement is expected (Lasni, 2025).

The results suggest that, while the model is conceptually sound, improvements are needed to optimize its statistical fit. Several factors may explain the marginal results of the confirmatory factor analysis. First, the homogeneity of student responses, particularly the concentration around response options 3 and 4, limited the variability of the data. Second, the presence of items with relatively low factor loadings, such as item 18, indicates that some items may not optimally represent the intended construct (Reis, 2025)Furthermore, student motivation may be more complex than a two-factor structure, suggesting the possibility of additional latent dimensions.(Amalia et al., 2024). These results do not weaken the instrument, but on the contrary provide clear directions for its improvement (Shofiaty, 2025).

Overall, this study makes a significant contribution by proposing an empirically validated and context-appropriate instrument that fills a previously identified gap in measuring learning motivation in problem-based learning (PBL) physics education. The instrument exhibits high reliability and acceptable structural validity, making it suitable for initial application in schools. Furthermore, it offers practical value to teachers for assessing student motivation and to researchers for evaluating pedagogical approaches (Aidoo et al., 2024). Future research should focus on refining the instrument by revising the items, increasing the sample size, and testing it in various educational settings to improve the model's fit and generalizability. This will make the instrument a more robust and broadly applicable tool (Dianty, 2026). Ultimately, this study establishes a solid foundation for the continued development of motivation assessment in physics education, thereby contributing to more effective and data-driven implementation of problem-based learning and improved learning outcomes (Hardiyanti et al., 2023).

CONCLUSION

This study successfully developed a non-standardized instrument to measure student learning motivation on the theme of "Work and Energy" within the context of problem-based learning (PBL). The instrument demonstrated excellent reliability (Cronbach's alpha = 0.95) and good structural fit (KMO and Bartlett tests). Exploratory factor analysis (EFA) identified two main dimensions: intrinsic and extrinsic motivation, together explaining 53% of the total variance, indicating a relevant representation of the measured construct. Although confirmatory factor analysis (CFA) suggests a marginal fit to the model, the instrument remains acceptable as a preliminary measurement tool, with significant potential for improvement. This instrument can serve as a valuable resource for teachers and researchers seeking to assess student learning motivation and develop more effective, student-centered teaching strategies. Further studies are recommended to improve item quality, increase sample size and conduct further validation with diverse populations and learning contexts, with the aim of improving model generalizability and fit.

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