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Feasibility of a Micro: bit-Based Gravitational Acceleration Measuring Instrument for Physics Learning

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Abstract: This research focused on assessing validity and reliability of a Micro: bit gravitational acceleration measuring device designed around problem based learning model approach. A research and development (R&D) framework was adopted, guided by four model which encompasses four phases: Define, Design, Develop, and Disseminate. The product assessment was conducted by three evaluators representing material expertise, media, as well as practitioner. The Aiken's V coefficient was applied to asses product validity and Cronbach's alpha coefficient was used to reliability instruments. Results showed that the material, media, and practitioner validation scores were 0.94, 0.95, and 0.96, respectively, with an overall mean validity coefficient of 0.95, categorized as highly valid. The reliability coefficients were 0.85 for material validation, 0.82 for media validation, and 0.88 for practitioner validation. These results indicate that the validation instruments demonstrated good internal consistency and indicating developed product satisfied validity standards. Micro: bit gravitational acceleration measuring instrument is considered suitable for further development as a physics learning medium integrated with PBL.

Keywords: Feasibility; Gravitational acceleration; Micro: bit; Reliability; Validity

Introduction

Physics education requires learning activities that enable students to connect theoretical concepts with observable physical phenomena through scientific investigation (Flegr et al., 2023). Experimental learning provides opportunities for students to collect empirical data, analyze observations, and develop evidence-based explanations (Wan, 2023). Research comparing physical and virtual investigations has examined their contributions to students' conceptual knowledge acquisition (Muilwijk & Lazonder, 2023). Furthermore, integrating virtual experiments can provide complementary learning experiences (Wörner et al., 2022).

Digital technologies have expanded opportunities to integrate measurement, data acquisition, and visualization into physics experiments (Wahyudi et al., 2024). Research on digital data acquisition systems highlights the importance of teachers' technological competencies in implementing technology-supported physics activities (Benz & Ludwig, 2023). Augmented reality experiments have also been investigated as technology-supported approaches to physics teaching (Freese et al., 2023). In addition, research on digital learning environments has explored how technology can support scientific observation and learning activities (Lechner et al., 2024).

Micro: bit is a programmable Micro: bitcontroller that can connect computational activities with scientific investigations (Balamuralithara et al., 2021). A systematic review of Micro: bit applications identified its use across various fields of science education (Quyen et al., 2023). Research on Micro: bit STEM education has examined its potential to facilitate interdisciplinary understanding and addressing concept (Mardian & Azzahra, 2024). The implementation of programmable devices in science projects also provides opportunities to connect computing with practical scientific activities (Tzagkaraki et al., 2024).

Through the exploration of real-world challenges, students are encouraged to investigate, develop analytical reasoning, and formulate appropriate solutions within the Problem-Based Learning (PBL) framework (Dewi et al., 2023). Comprehensive analysis physics education identified the potential contribution of PBL to academic achievement (Nicholus et al., 2023). Research on exploratory problem-solving has also examined learning approaches in which engage problem solving activities (DeCaro et al., 2023). Reviews of PBL

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implementation in physics education further highlight the importance of examining how this model (Silva et al., 2024).

Design an educational product requires systematic evaluation to establish its suitability for the intended learning context (Haastrecht et al., 2024). Expert judgment can be used to examine the relevance and appropriateness of the components included in an educational instrument (Anggara & Abdillah, 2023). Research on educational instrument validation has demonstrated the use of Aiken's V to quantify expert judgments of content validity (Noviana et al., 2023). Further methodological research has examined used to evaluate validation content (Kania et al., 2024).

Although previous studies have examined Micro: bit applications in science education and PBL in physics learning, the validity of a Micro: bit gravitational acceleration measuring instrument integrated with PBL requires specific investigation. Research on PBL and metacognition in physics education provides further context for considering the learning processes supported by problem-oriented instruction (Widyaningsih et al., 2024). A meta-analysis has also examined the contribution of PBL to students' physics problem-solving abilities (Janna et al., 2024). Therefore, this study aimed asses validity, developed instrument through material, media and a physics teacher as a practitioner.

Method

Research Design

This study employed a research and development (R&D) approach using the Four-D (4D) development model proposed by Thiagarajan et al. (1974). This article focuses on the validity and reliability assessment Micro: bit gravitational acceleration measuring instrument.

Product Development

The developed product was a Micro: bit instrument designed to measure gravitational acceleration through pendulum experiments. The instrument was integrated with the PBL model to support problem-oriented experimental activities. Development steps included the instrument preparation, supporting learning materials, followed by expert assessment and product revision based on the validation results.

Validity and Reliability Procedure

Product validation involved three assessment instruments: media validation, material validation, and practitioner validation, each consisting of 25 assessment items. Media validation focused on the design, technical aspects, and suitability of the product as a physics learning medium, while material validation examined the accuracy and suitability physics material. Practitioner validation assessed the product's relevance to classroom learning and its suitability for physics experimental activities. These analyses were conducted to establish the validity and reliability media to product development.

Study evidence were collected using validation sheets completed by the respective validators. Beyond assigning numerical scores for assessment items, the evaluators offered recommendations for product improvement. Validity results were analyzed separately for each aspect. Product was subsequently refined response, including addition of a user manual containing the product description, component functions, operating procedures, experimental steps, and safety instructions.

Data Analysis Technique

Product Feasibility

Product feasibility was analyzed through validity and reliability testing. Product validity was analyzed based on the validators' assessment scores using the following equation:

$$V = \frac{\text{Total Validator Score}}{\text{Maximum Possible Cardl}} \times 100\% \quad (1)$$

A further analysis was conducted by combining the scores from all validators to determine the overall validity level using Aiken's formula (Aiken, 1985):

$$V = \frac{\bar{x}_1 + \bar{x}_2 + \bar{x}_3}{n} \quad (2)$$

Where:

V : Validator Agreement Index

$\bar{x}_1, \bar{x}_2, \bar{x}_3$: Total Score Given the Raters

n : Number of Validators

The results of the validity analysis were interpreted using the following criteria.

Table 1. Validity Interpretation

Validity Value	Interpretation
$V \geq 0.80$	Highly Valid
$0.60 \leq V < 0.80$	Valid
$0.40 \leq V < 0.60$	Moderate Valid
$V < 0.40$	Less Valid

(Aiken, 1985)

Reliability analysis was also conducted to assess internal consistency media, material, and practitioner validation instruments and to ensure that the assessment items consistently measured the intended aspects using Cronbach Alpha.

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \left(\frac{\sigma \sum_i^2}{\sigma_t^2}\right)\right) \quad (3)$$

Where:

α : Reliability Coefficient (Cronbach's Alpha)

k : Number of Items or Validators

$\Sigma\sigma_i^2$: Sum of the Variances of Each Item Validator

σ_t^2 : Total variance

The interpretation of Cronbach's alpha reliability coefficients was accordance established standards presented Table 2. These criteria were used to determine the level of reliability of the validation instruments.

Table 2. Reliability coefficients

Reliability Value	Interpretation
≥ 0.90	Highly Reliable
0.80 – 0.89	Reliable
0.70 – 0.79	Moderate Reliable
0.60 – 0.69	Low Reliable
< 0.60	Unreliable

(Aiken, 1985)

Reliability tested using Cronbach's alpha was conducted with SPSS version 25.

Result and Discussion

Product Validity

Product validation was conducted during the Develop stage of the Four-D (4D) research and development model. The validation process involved three validators: a material expert, a media expert, and a practitioner. Three assessment instruments were used to evaluate the product, namely material validation, media validation, and practitioner validation. Each instrument consisted of 25 assessment items. The data obtained from the validation process were analyzed using Aiken's V coefficient. Findings validity analysis are presented in table 3 and Figure 1.

Table 3. Results of product validity analysis

Validation Aspect	Validity Value	Interpretation
Material	0.94	Highly Valid
Media	0.95	Highly Valid
Practitioner	0.96	Highly Valid
Overall Mean	0.95	Highly Valid

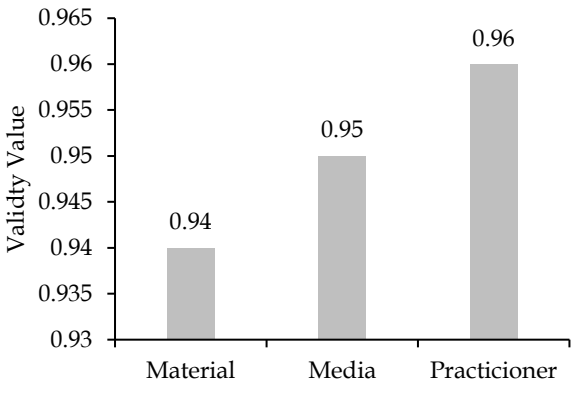


Figure 1. Validity Results

Table 3 and Figure 1 shows that all validation aspects achieved high validity coefficients. The material validation obtained a coefficient of 0.94, indicating that the physics content and learning materials met the established validity criteria. The media validation achieved a coefficient of 0.95, suggesting that the product's design and technical characteristics were considered appropriate as a physics learning medium. Meanwhile, practitioner validation obtained the highest coefficient, at 0.96, indicating that the product was considered relevant to classroom learning and physics experimental activities. The overall mean validity coefficient was 0.95, which falls within the highly valid category.

Findings validity analysis summarized table 3 and Figure 1. Every aspects achieved high validity coefficients. Material validation obtained a coefficient of 0.94, indicating that the physics content and learning materials met the established validity criteria. Media validation achieved a coefficient of 0.95, suggesting that the product's design and technical characteristics were considered appropriate as a physics learning medium. Meanwhile, practitioner validation obtained the highest coefficient, at 0.96, indicating that the product was considered relevant to classroom learning and physics experimental activities. The overall mean validity coefficient was 0.95, which falls within the highly valid category.

These findings indicate that the developed instrument met the validity criteria across the three assessment aspects. The high material validity score suggests that the product's content was considered suitable for supporting the learning of gravitational acceleration through pendulum experiments. The media validity result indicates that the product's design and technical features were considered appropriate for its intended educational purpose. Furthermore, the practitioner assessment supports the product's potential use in physics learning activities. This finding is consistent with Aiken (1985), who described coefficients for analyzing the validity of ratings and emphasized the use of expert judgments in evaluating content-related validity.

The validity results of the present study can be compared with those reported by Zavira & Sari (2023), who evaluated an instrument for assessing student learning activities in physics using Aiken's V. Their study obtained a validity coefficient of 0.778, which was interpreted as moderate validity. In comparison, the present study achieved coefficients of 0.94 for material validation, 0.95 for media validation, and 0.96 for practitioner validation. These results indicate that the developed Micro: bit gravitational acceleration measuring instrument achieved higher validity coefficients than the physics learning activity instrument examined by Zavira & Sari (2023). However, the comparison should be interpreted cautiously because

the two studies evaluated different types of instruments and educational products. The findings nevertheless demonstrate the importance of expert assessment in establishing the content and suitability of educational products before their implementation.

A related comparison can be drawn from Noviana et al. (2023), who assessed the validity of an instrument for analyzing digital learning resources related to disaster education in coastal areas. Their study involved eight raters and found that the validity of the assessment items varied across categories, with some items requiring editorial revisions. Similarly, the present study identified the need to improve the product's user manual despite obtaining high validity coefficients. This comparison highlights that quantitative validity scores should be accompanied by qualitative feedback to identify areas requiring improvement. While Noviana et al. (2023) focused on validating an instrument for needs analysis, the present study evaluated a physical learning device intended for pendulum experiments. Its contribution lies in demonstrating high expert-assessed validity across material, media, and practitioner aspects for a Micro: bit gravitational acceleration measuring instrument.

Reliability Product

Reliability analysis was conducted to determine the internal consistency of the material, media, and practitioner validation instruments. Cronbach's alpha was used to analyze the reliability coefficients, with the calculations performed using SPSS version 25. The results are presented in Table 4 and Figure 2.

Table 4. Results of reliability product

Reliability Aspect	Cronbach's Alpha	Interpretation
Material	0.85	Reliable
Media	0.82	Reliable
Practitioner	0.88	Reliable
Overall Mean	0.85	Reliable

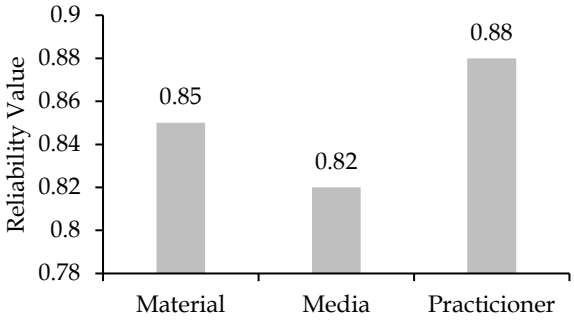


Figure 2. Results of reliability product

As shown in Table 4 and Figure 2 the material validation instrument reliability of 0.85, while the media validation instrument obtained a coefficient of 0.82. The practitioner validation instrument achieved the highest, at 0.88. Overall mean reliability coefficient was 0.85. According to reliability interpretation, all three validation instruments were categorized as reliable.

The results indicate that the validation instruments demonstrated satisfactory internal consistency according to the criteria applied in this study. The coefficient of 0.88 for practitioner validation suggests that this instrument had the highest internal consistency among the three instruments. Meanwhile, the coefficients of 0.85 and 0.82 for material and media validation, respectively, also met the study's reliability criteria. These findings support the use of the three instruments to collect validator assessments of the developed product.

The reliability results can be compared with those of Novika & Istiyono (2023), whose research focused on creating a physics-based assessment tool for secondary-level students' competency evaluation. Their study reported fell within very reliable category. Similarly, all of which were classified as reliable according to the criteria adopted. Both studies demonstrate the importance of examining reliability during the development of physics education instruments. However, the instruments served different purposes: Novika & Istiyono (2023) evaluated a physics competency assessment instrument, whereas the present study examined the internal consistency of instruments used to validate a learning device. Therefore, the comparison supports the importance of reliability testing while recognizing differences in assessment objectives and instrument characteristics.

Further comparison can be made with Handayani et al. (2023), who examined concept mastery media on electricity using the Rasch model. Hidayah & Muhtarom (2023) reported high level reliability assessment materials. Coefficient obtained research fall between the reported values, ranging from 0.82 to 0.88. These comparisons illustrate that reliability coefficients may vary according to instrument characteristics, assessment purposes, and the data analyzed. Nevertheless, all three validation instruments in the present study met the adopted reliability criteria. It is important to note that reliability evaluates assessment items validation instruments and does not directly establish the measurement accuracy or repeatability of the physical device.

Conclusion

The developed product demonstrated a substantial level of validity. Overall validity coefficient of 0.95 indicated product established for validity across the

material, media, and practitioner aspects. The material, media, and practitioner validation coefficients were 0.94, 0.95, and 0.96, respectively. Results indicate product demonstrate suitability physics media, technical, relevance to classroom learning and experimental activities. This research showed that the three validation assessment tools exhibited satisfactory consistency evaluation components. Revisions based on validator feedback, particularly improvements to the user manual, further supported product refinement. Overall, the findings support the suitability of the developed instrument for further evaluation as a physics learning medium integrated with PBL. Future research should examine its practicality in classroom settings, measurement accuracy, and effectiveness in supporting students.

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Author Contributions
M.A.I. conceptualized the research idea, developed the research method, conducted the data collection and analysis, developed the Micro: bit gravitational acceleration measuring instrument, and prepared the original manuscript; A.D. and A.H. contributed to the research design, product assessment, critical examination, and manuscript refinement. The final article was reviewed and approved by all contributors.

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Conflicts of Interest
The authors declare no conflict of interest.

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