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# Development of Gamification-Based Mobile Learning to Improve Learning Outcomes for Automotive Measurement Tools

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## Abstract

Inclusive education, a key priority of SDG 4, requires learning innovations that are accessible and engaging for all learners, including students with disabilities. In Indonesian inclusive schools, limited availability of adaptive learning technology remains a major barrier, particularly for students with mild intellectual disabilities who often struggle with practical competencies such as reading precision measuring tools. This study developed and evaluated a gamification-based mobile learning (m-learning) medium on automotive measurement tools (vernier calipers) tailored to the needs of students with mild intellectual disabilities through accessible design elements (preferred colors, readable fonts, simplified sentences, and adapted assessments). Using a Research and Development (R&D) approach with the ADDIE model, the product was validated by one media expert and one material expert, and its effectiveness was examined through a one-group pretest–posttest design with 35 Grade 10 Automotive Engineering students at SMK Palapa Semarang. Expert validation results indicated that the media was very feasible, with scores of 85% (Display Design), 83% (Technical Quality), 88% (Visual Communication), and 90% (Media Attractiveness), while content feasibility was also very feasible, with 82% (Content Completeness), 87% (Content Accuracy), 84% (Presentation Cohesion), and 86% (Language Use). Student learning outcomes improved substantially, with mean scores increasing from 68.29 (pretest) to 88.86 (posttest), yielding a gain of 20.6 points and reduced score variability (SD from 10.43 to 6.31). These findings suggest that gamification-based m-learning designed using assistive technology principles is feasible and can enhance learning outcomes in inclusive vocational education contexts.



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## INTRODUCTION

Inclusive education is one of the key components of Sustainable Development Goal (SDG) 4 across all educational levels, early childhood, primary, secondary, and higher education (Chankseliani & McCowan, 2021; Prieto-Jiménez et al., 2021). Inclusive education aims to ensure equitable and high-quality education while promoting lifelong learning opportunities for all (Rad et al., 2022). It not only emphasizes accessibility for all learners, including those with special needs, but also highlights the importance of equal and relevant learning quality (Hernández-Torrano et al., 2020). To achieve this goal, innovation in the learning process is required to effectively reach all students in engaging and meaningful ways.

One of the major challenges in inclusive education is creating learning environments that support and motivate all students, including those with disabilities (Faulkner et al., 2020; Vetoniemi & Kärnä, 2021). Many students, particularly students with disabilities, continue to face barriers in understanding learning materials due to educational technologies that are not adapted to their needs (Iskandar et al., 2020). The World Bank reported that the availability of learning technologies for students with disabilities in inclusive schools in Indonesia remains very limited. Nearly 70% of GPK (teachers trained in inclusive education working in inclusive schools) do not have access to appropriate learning technology, even though they have students with disabilities in their classrooms, while approximately 80% of teachers in special schools (SLB) do (Hata et al., 2023). Therefore, more interactive and adaptive learning approaches are needed to ensure that every student receives education tailored to their needs.

According to data from the Ministry of Education, Semarang City has 725 students with disabilities at the secondary education level (including SMPLB and SMALB) in the second semester of 2024 (Kemdikbud, 2025). One vocational school that implements inclusive education is SMK Palapa Semarang, with 2 students with disabilities out of 700 validated students. Both of these students are enrolled in the Motorcycle Engineering and Light Vehicle Engineering programs. Based on an interview with one of the productive subject teachers in TOKR, Ms. Siti Ira Amalia, S.Pd., the students are identified as having mild intellectual disabilities. They experience difficulties performing practical tasks using existing hand tools and measuring instruments. Mild intellectual disabilities are characterized by an IQ score of 50–70, compared to the normal range of 91–110, yet these students are still considered educable (Fiksinski, 2021).

SMK Palapa Semarang implements the Merdeka Curriculum. In the Automotive Engineering program, the learning element on workplace tools and equipment is taught in Phase E (Grade 10). The learning outcome for this element states that students are able to use workplace tools and equipment, including preparation, calibration, and appropriate usage based on type, function, and repair manuals (Badan Standar Kurikulum dan Asesmen Pendidikan, 2022). The instructional materials, therefore, include hand tools and automotive measuring instruments such as mechanical, electrical, electronic, hydraulic, and pneumatic measurement tools (Direktur Jenderal Pendidikan Dasar dan Menengah, 2018). Mastery of workplace tools and equipment serves as a foundational competency for practical learning. Thus, all students, including those with disabilities, must be competent in using, reading, and maintaining measuring instruments. According to the teacher, student learning outcomes (normal and students with disability) remain low in operating and reading measurement tools, such as vernier calipers, due to the precision spacing of the scale, where the smallest division may have a sensitivity of 0.05 millimeters or 0.02 millimeters.

Teachers must make specific efforts to ensure inclusive learning is effective and efficient. One of these efforts is the development of instructional media that supports inclusive learning. M-learning refers to the use of mobile or handheld information technology devices in the learning process. In inclusive education, m-learning must be accessible for learners with diverse functional abilities and support student-centered learning (Chen & Tsai, 2021). A literature review study shows that m-learning can improve autonomy, quality of life, interest, learning motivation, knowledge acquisition, and digital competency development among students with disabilities (Gentry et al., 2019; Palomino, 2022).

Alongside the advancement of science and technology, gamification has become an increasingly popular learning method in Indonesia and is even recommended by the Ministry of Education (Tamur,2021; Direktorat Pembelajaran dan Kemahasiswaan Kemdikbudristek, 2023). Gamification involves the implementation of game-based elements in the learning process, such as challenges, points, badges, leaderboards, and reward mechanisms (Zainuddin et al., 2021; Abril & Gimenez-Fernandez, 2024). This method can enhance

learning outcomes and student motivation by making learning more enjoyable and interactive (Lampropoulos et al., 2022; Oliveira et al., 2022).

The purpose of this study is to develop gamified learning media to (1) determine the feasibility of gamification-based mobile learning and (2) determine the improvement in student learning outcomes at Palapa Semarang Vocational School after using gamification-based mobile learning.

Previous studies have only developed gamification-based learning without considering established guidelines for assistive technology design. In this study, the gamification-based m-learning will be adapted to the specific needs of students with mild intellectual disabilities. The design adjustments will include the use of preferred colors, accessible and readable font types, and simplified sentence structures to improve accessibility and ensure that the learning content is easy to understand. Additionally, the assessment items will also be modified to align with the cognitive characteristics of learners with mild intellectual disabilities.

## RESEARCH METHODS

A. Research Design

This study employed a Research and Development (R&D) approach using the ADDIE instructional design model (Analysis, Design, Development, Implementation, and Evaluation). The R&D process was conducted using a quantitative approach and implemented through an experimental method with a pre-experimental One-Group Pretest–Posttest Design to examine learning outcomes.

Table 1. Research Design for Student Learning Outcomes

| Group | Pretest | Treatment | Posttest |
|---|---|---|---|
| A | O1 | X | O2 |

The ADDIE model consists of five stages: (1) Analysis: identifying the need to develop the Gamification-Based M-Learning. This includes problem analysis, learner needs analysis, and instructional content analysis related to measurement tools. (2) Design: selecting and organizing instructional materials on automotive measurement tools, choosing proper software, designing a storyboard, developing research instruments, and creating the initial design of the m-learning application. (3) Development: validating both the research instruments and the Gamification-Based M-Learning through expert judgment to determine feasibility. (4) Implementation: applying the developed product to Grade 10 Automotive Engineering students at SMK Palapa Semarang. (5) Evaluation: determining whether the Gamification-Based M-Learning improves student learning outcomes. At this stage, pretests and posttests with multiple-choice questions were administered.

B. Research Setting and Participants

The object of this research is the Gamification-Based M-Learning on the topic of automotive measurement tools. The study was conducted with Grade 10 Automotive Engineering students at SMK Palapa Semarang during the even semester of the 2024/2025 academic year.

C. Data Collection Instruments

Data were collected using two types of research instruments: (1) Questionnaires with a Likert scale (media expert validation, material expert validation, and student responses), and (2) Multiple-choice tests for the pretest and posttest consisting of 5 answer options. All research instruments were validated by expert lecturers prior to their use in the data collection process.

D. Data Analysis Techniques

1. Expert Feasibility Analysis

Media and material expert questionnaires were administered to determine the feasibility of the developed m-learning product. The feasibility score was calculated using Formula 1 (Pramuningtyas & Dewi, 2024). The results were then compared with the feasibility criteria in Table 2.

$$P = \frac{\sum n}{\sum N} \times 100\% \quad (1)$$

Description:
P = Percentage of Learning Media Feasibility
∑n =Total score obtained
∑N = Maximum possible score

Table 2. Feasibility Criteria for Gamification-Based M-Learning

| Category | Percentage |
|---|---|
| Very Feasible | 81%–100% |
| Feasible | 61%–80% |
| Fairly Feasible | 41%–60% |
| Less Feasible | 21%–40% |
| Not Feasible | 0%–20% |

2. N-Gain Analysis

N-Gain analysis was used to determine the magnitude of improvement in students' motivation and learning outcomes before and after the treatment. It was calculated using the Formula 2 (Hake, 2024).

$$\text{N-Gain} = \frac{S_{\text{posttest}} - S_{\text{pretest}}}{S_{\text{max}} - S_{\text{pretest}}} \quad (2)$$

Description:
Sposttest = Posttest Score
Spretest = Pretest Score
Smax = Maximum Possible Score

The N-Gain results were classified following criteria adapted from Afifah et al. (2019), which state that: N-Gain is considered high if > 0.7; N-Gain is considered moderate if 0.3 < N-Gain ≤ 0.7; and N-Gain is considered low if < 0.3 (Hake, 1998).

## RESULT AND DISCUSSION

### A. Analyze Stage

The analysis stage aims to examine several aspects related to the research to be conducted. This stage consists of six components: problem analysis, instructional goal analysis, learner analysis, resource analysis, and learning implementation plan analysis.

Problem analysis was conducted to identify obstacles in the learning process. Based on the preliminary study, assessment results showed that not all students achieved scores above the minimum mastery criteria (KKM).

Instructional goal analysis was carried out to translate general learning objectives into more specific and observable objectives, arranged logically and systematically. These objectives refer to the stated learning outcomes of the "Workplace Tools and Equipment" element in Phase E of the Automotive Engineering Basics. The expected learning outcome states that students are able to select, use, and maintain general tools, equipment tools, special service tools, measuring tools, and diagnostic tools.

Learner analysis was conducted to determine student learning characteristics. The students are aged 16–17 years old. Their dominant learning styles are kinesthetic, followed by visual and auditory learning.

Resource analysis was performed to identify the available resources that support the learning process. Observations showed that students who have smartphones and internet data are skilled in using smartphones, have access to school Wi-Fi, and are allowed to use smartphones for learning activities.

The analysis of the learning implementation plan was carried out to review the teaching documents used in the school. The results indicate that the school has a well-documented syllabus and learning implementation plan using a variety of instructional models, methods, and media.

### B. Design Stage

The design stage aims to plan and design essential components to be applied in developing the gamification-based learning media. Activities in this stage include developing learning objectives, creating a storyboard, selecting software, gathering instructional materials, and developing assessment questions with answer keys.

From the instructional goal analysis, specific learning outcomes were identified. These outcomes were further mapped based on the measurement tools to be taught. Among many measurement tools, the focus is on the vernier caliper. Two core competencies were identified: (1) students apply mechanical measuring tools (vernier calipers), and (2) students are able to use vernier calipers. These were then translated into the following learning objectives:

After using the gamification-based learning media on vernier calipers, students are expected to: (1) explain the definition of a vernier caliper accurately; (2) describe terminologies and types of vernier calipers accurately; (3) identify the parts of a vernier caliper correctly; (4) determine the precision level of a vernier caliper correctly; (5) analyze the measurement procedures of a vernier caliper correctly; (6) read measurement results using a vernier caliper correctly.

A storyboard served as the initial visual design that guided the development of instructional media so that it was structured, understandable, and aligned with learning objectives. Its elements include visuals (images, backgrounds), narration (text), audio (background music, sound effects), and other UI information such as navigation buttons. The storyboard begins with a prompt using an image of a vernier caliper as an attention grabber. The following slides include: a welcome page, a main page containing a competency menu, material menu, video menu, quiz menu, game menu, profile menu, instructions menu, and reference menu.

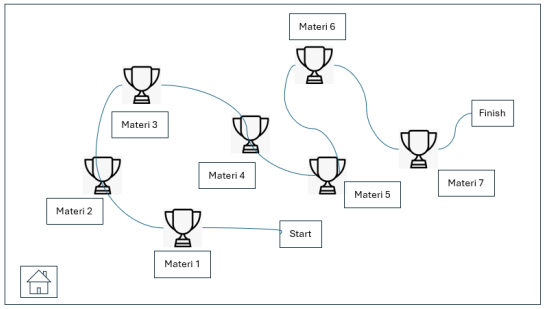


Figure 3. Storyboard of the learning media


Figure 4. The material is made challenging (easy, medium, difficult)

Software selection was adjusted to usability and accessibility. After analyzing different educational media development tools, PowerPoint was selected because it is the simplest and most flexible software to use. The final product is converted into an .apk file using 2APK Builder. Learning materials, including text, images, videos, and animations, were collected from textbooks, modules, YouTube, and academic articles. Multiple-choice test items (5 answer options per item) were developed based on learning objectives, with 4–5 items per objective. Questions were embedded in learning content, practice quizzes, and gamified assessments.

C. Development Stage

The development stage aims to produce a final product that is ready for classroom implementation. Activities included developing the m-learning application following the storyboard, designing expert validation questionnaires, and conducting feasibility tests with material and media experts.

The gamified learning media was developed using Microsoft PowerPoint, with primary menu designs created in Canva. The PowerPoint project was converted to HTML and then packaged as an m-learning application (.apk) using 2APK Builder.

Validation instruments for media experts and material experts were created. The media expert instrument consisted of four aspects: Display Design, Visual Communication, Technical Quality, and Media Attractiveness. Statements for these aspects can be seen in Table 5.

The material expert instrument measured aspects of Content Completeness, Content Accuracy, Presentation Cohesion, and Language Use. Based on these aspects, 12 statements from the Material Expert Validation Instrument are presented in Table 6.

Table 5. Media Expert Validation Instrument Statements

| No | Statement |
|---|---|
| 1 | The media display is visually appealing and appropriate for the learning content. |
| 2 | The text is easy to read (suitable font type, size, and contrast). |
| 3 | The layout is proportional, organized, and neat. |
| 4 | Navigation and buttons are easy to use and user-friendly. |
| 5 | Usage instructions are clear and easy to understand. |
| 6 | The media runs smoothly without technical issues. |
| 7 | The vernier caliper illustrations/images are clear and accurate. |
| 8 | The animations/simulations align well with the measurement concepts. |
| 9 | Icons and symbols are consistent and not confusing. |
| 10 | The media successfully captures students' attention. |
| 11 | The media improves students' learning motivation. |
| 12 | The media provides an enjoyable and engaging learning experience. |

Table 6. Material Expert Validation Instrument Statements

| No | Statement |
|---|---|
| 1 | The instructional content aligns with the established learning objectives. |
| 2 | The example questions are appropriate for the learning objectives. |
| 3 | The media provides practice questions to assess students' understanding. |
| 4 | Measurement concepts using a vernier caliper are presented correctly. |
| 5 | Terminology and measurement procedures using a vernier caliper are accurate. |
| 6 | There are no factual or conceptual errors. |
| 7 | The sequence of material presentation is systematic and well-organized. |
| 8 | The connections between subtopics are clear and logical. |
| 9 | Illustrations/animations effectively support the explanation of concepts. |
| 10 | The sentences are concise and free from redundancy. |
| 11 | The language used adheres to proper grammar and writing conventions. |
| 12 | There are no spelling or typographical errors. |

Both instruments were validated for accuracy and appropriateness before use. After validation, the instruments were administered to one media expert and one material expert. The

average feasibility scores are shown in the figure below.

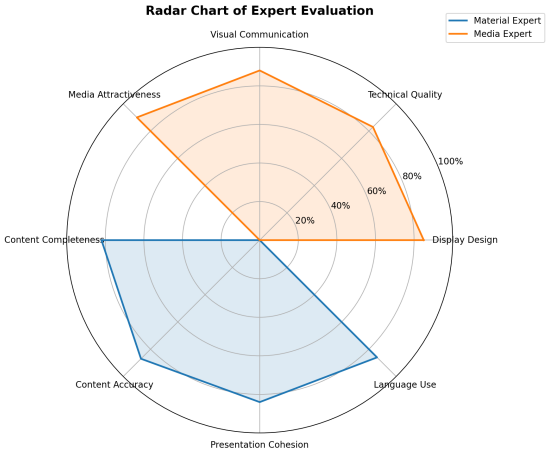


Figure 4. Expert evaluation results

Expert feedback indicated: Media Expert: Display Design (85%), Technical Quality (83%), Visual Communication (88%), Media Attractiveness (90%). All aspects are very feasible. Material Expert: Content Completeness (82%), Content Accuracy (87%), Presentation Cohesion (84%), Language Use (86%). All aspects are very feasible. The primary suggestion for improvement was to increase the color contrast between the background and the text for better readability.

D. Implementation Stage

The m-learning media was implemented at SMK Palapa Semarang on May 15, 2025. The research permit issued by the Faculty of Engineering is available at https://siradi2.unnes.ac.id/file-surat/7TMhgjWyeW.

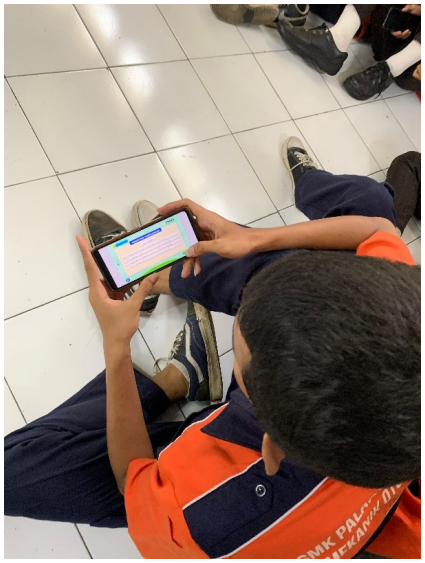

Figure 5. Students completing practice questions

Figure 5 shows the implementation stage of the m-learning media for students using mobile phones. The research subjects were 35 tenth-grade students of the Light Vehicle Engineering program. Before using the m-learning media, the students completed a pretest. After learning with the gamification-based m-learning media, they completed a posttest. Documentation of data collection can be accessed here: https://drive.google.com/drive/folders/1zP-Ok3c75HqUBtxtlKuvS3IMYuaeiyXD.

Pretest and posttest results were tabulated and analyzed. Score distributions are shown in Table 7. Mean, Median, and Standard Deviation can be seen in Table 8.

Table 7. Pretest and Posttest Score Distribution

| No | Interval Score | Frequency Pretest | Frequency Posttest |
|---|---|---|---|
| 1 | 0-10 | 0 | 0 |
| 2 | 11-20 | 0 | 0 |
| 3 | 21-30 | 0 | 0 |
| 4 | 31-40 | 1 | 0 |
| 5 | 41-50 | 2 | 0 |
| 6 | 51-60 | 9 | 0 |
| 7 | 61-70 | 14 | 0 |
| 8 | 71-80 | 8 | 9 |
| 9 | 81-90 | 1 | 21 |
| 10 | 91-100 | 0 | 5 |
| Total | | 35 | 35 |

Table 8. Mean, Median, and Standard Deviation

| | Mean | Median | SD |
|---|---|---|---|
| Pretest | 68,29 | 70.0 | 10.43 |
| Posttest | 88,86 | 90.0 | 6.31 |

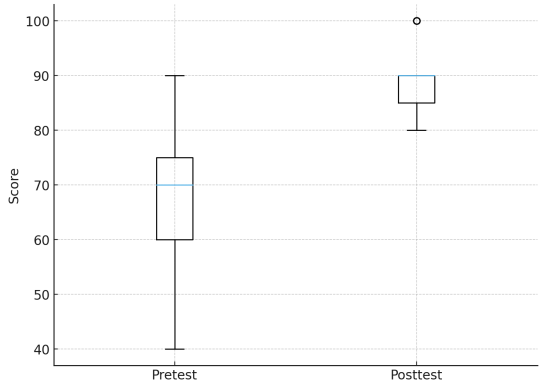


Figure 6. Pretest and Posttest Boxplot

Based on the results, the pretest mean score was 68.29, while the posttest mean score increased to 88.86, indicating a significant gain of 20.6 points after the intervention. The pretest median score was 70, and the posttest median score was 90. The pretest standard deviation was 10.43, indicating a wide score distribution. In

contrast, the posttest standard deviation was reduced to 6.31, indicating more homogeneous performance after learning intervention, with the majority of students achieving high scores.

## CONCLUSION

This study concludes that the gamification-based mobile learning (m-learning) product developed through the ADDIE model is highly feasible and effective for supporting inclusive vocational learning on automotive measurement tools (vernier calipers). Expert validation confirmed media aspects 86.5% very high feasibility (display design, technical quality, visual communication, and attractiveness) and material aspects 84.75% very high feasibility (content completeness, accuracy, presentation cohesion, and language), indicating that the product is appropriate for classroom implementation. Implementation with 35 Grade 10 Automotive Engineering students at SMK Palapa Semarang showed a substantial improvement in learning outcomes, as evidenced by a marked increase in mean scores from pretest to posttest and a more homogeneous score distribution after the intervention. Overall, integrating gamification with accessible design considerations aligned with the needs of students with mild intellectual disabilities can strengthen engagement and significantly enhance learning achievement in inclusive vocational education settings.

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