IJECA (International Journal of Education & Curriculum Application)
Journal homepage: http://journal.ummat.ac.id/index.php/IJECA
ISSN 2614-3380 | Vol. 9, No. 2, August 2026
https://doi.org/10.31764/ijeca.v9i2.38842

# Development of an IoT-Based Digital Measuring Instrument Training Kit as an Interactive Learning Tool to Boost Students' Interest in Learning

**Nursina Sari[1*], Linda Sekar Utami[2]**
[1]Elementary School Teacher Education Program, Universitas Muhammadiyah Mataram, Indonesia
[2]Physics Education Program, Universitas Muhammadiyah Mataram, Indonesia
Author Corresponding: sarinursina1234@gmail.com

**ABSTRACT**

This study developed an IoT-based digital measuring instrument training kit to enhance the learning motivation of students on the Primary School Teacher Education programme. Given that practical activities relating to measurement in the 'Basic Concepts of Primary School Physics' course are still considered challenging, and that the integration of digital technology into teaching remains limited, this IoT-based training kit is designed to bridge the gap between theory and practice. This research is a research and development (R&D) study that adapts the Borg and Gall model, applied in a pilot study and a large-scale trial at the PGSD UMMAT. Data were collected using an expert validation questionnaire, a student response questionnaire, and a learning interest questionnaire, and were subsequently analysed using a paired sample t-test, N=Gain, and descriptive statistics. The validation results indicated a feasibility level of 84.94%, categorised as 'highly feasible'. The practicality test yielded an average score of 3.62, representing 72.4% in the 'practical' category. Statistical analysis using a paired-sample t-test revealed a significant difference between learning interest scores before and after the intervention (Sig. 0.000 < 0.05). The N-gain value of 0.54 falls into the moderate category. The use of an IoT-based digital measuring instrument training kit significantly increased active engagement and improved students' ability to use IoT-based digital measuring instruments during practical learning activities, whilst also aiding their understanding of measurement concepts, thereby demonstrating that the use of modern measuring instruments is effective in boosting the learning interest of Primary School Teacher Education (PGSD) students.

**Keywords:** Digital Measuring Instruments; IoT; Students; Interest in Learning; Training Kit.

**Article History:**
Received: 19-03-2026
Revised : 18-04-2026
Accepted: 01-05-2026
Online : 01-08-2026

***How to Cite (APA style):***
Sari, N., & Utami, L. S. (2026). Development of an IoT-Based Digital Measuring Instrument Training Kit as an Interactive Learning Tool to Boost Students' Interest in Learning. *IJECA (International Journal of Education and Curriculum Application)*, *9*(2), 454-467. https://doi.org/10.31764/ijeca.v9i2.38842



## 1. INTRODUCTION

The rapid development of digital technology in the era of the Fourth Industrial Revolution has brought about significant changes across various sectors, including higher education, particularly in the teaching of science and engineering (Shenkoya & Kim, 2023). This situation requires higher education institutions to transform their learning paradigms from traditional approaches towards models that systematically integrate digital technology to support the development of 21st-century competencies. In practice, the integration of digital technology into learning remains suboptimal, as the learning process often remains focused on the conventional delivery of content. Consequently, the development of essential skills such as digital literacy, critical thinking, creativity, and the ability to adapt to technological advancements has not been maximised. Yet, the increasingly complex dynamics of the industrial world demand graduates who not only master conceptual knowledge but also possess competencies relevant to industrial needs and global challenges (Purwanto et al., 2023).

In the delivery of teaching, particularly in courses focused on practical work and measurement, various issues are still encountered that result in low student engagement (Burke et al., 2021). These issues include the use of measuring instruments that remain conventional and are poorly integrated with digital technology, meaning that the learning process tends to be monotonous and fails to provide an interactive learning experience. Practical learning is not yet fully supported by contextual learning media that align with the latest technological developments, such as the use of digital systems and Internet of Things (IoT)-based connectivity (Ghashim & Arshad, 2023). This situation results in minimal active student engagement in the learning process, both in terms of conceptual understanding and the mastery of practical skills. These limitations also pose a challenge for educators in delivering innovative and relevant learning tailored to students' characteristics in the digital age (Ali et al., 2025).

The Internet of Things (IoT) is understood as a technological system that enables physical devices, equipped with sensors and connected via the internet, to collect, process and exchange data in real time (Gulati et al., 2022). In the field of education, particularly in practical sessions and measurement activities, the application of IoT through the development of a digital measurement Training KIT offers an innovative solution relevant to the needs of modern learning (Badshah et al., 2023). The advantages of this technology lie in the integration of precise digital sensors, continuous data connectivity, and the presentation of measurement results in the form of real-time visualisations, thereby supporting a more comprehensive understanding of concepts. The use of IoT-based Training Kits also enables the creation of interactive and authentic learning experiences, as students are directly involved in the measurement process, data analysis, and interpretation of results (Tariq et al., 2024).

The use of digital technology, particularly the Internet of Things (IoT), offers significant opportunities for developing innovative learning materials in the fields of engineering and vocational education (Zeeshan et al., 2022). Barashkin et al. (2023) noted that the use of digital measuring instruments in practical sessions leads to improved measurement accuracy, greater efficiency in the learning process, and enhanced conceptual understanding through the more systematic presentation of data. Technology-based interactive learning media are reported to contribute positively to increased learning interest and motivation among students (Halawa, 2024). The integration of digital sensors, real-time data visualisation, and smart devices fosters the creation of a more adaptive, contextual, and student-centred learning environment (Sitorus et al., 2025).

Training kits, as integrated learning tools, are designed to support self-directed learning as well as structured practical activities focused on hands-on experience (Mahmood et al., 2022). The use of training kits provides learners with the opportunity to engage actively in the process of exploration and experimentation, thereby facilitating the understanding of complex concepts and strengthening the link between theoretical aspects and practical application (Krutgeen & Hinon, 2025). The development of effective training kits generally takes into account the principles of ease of use, flexibility in implementation, and alignment with applicable learning standards, which ultimately contribute to increased student engagement and learning outcomes (Sabri et al., 2024). The integration of Internet of Things (IoT)-based technology further expands the functionality of training kits by providing real-time data, more representative visualisation of information, and enhanced interactivity throughout the learning process (Soghomonyan & Karapetyan, 2023).

Interactive learning media hold great potential for enhancing students' interest in learning, as they are capable of creating a more engaging, dynamic and meaningful learning process (Hartono et al., 2025). The use of interactive media encourages students' active engagement through direct participation in learning activities, thereby having a positive impact on learning motivation and the overall quality of the learning experience (Li et al., 2024). The effectiveness of implementing such media is heavily influenced by the readiness of supporting technological infrastructure and the competence of educators in integrating technology pedagogically (Nurhikmah et al., 2024).

Based on the above, this study aims to develop an IoT-based digital measuring instrument training kit to enhance the learning interest of Primary School Teacher Education (PGSD) students in practical learning activities covering measurement topics within the 'Basic Concepts of Primary School Physics' course. This study encompasses product development, validity and feasibility testing, as well as an analysis of its effectiveness in enhancing students' learning interest and engagement. The novelty of this research lies in the integration of digital measuring devices, IoT-based connectivity, and practical learning design into a single comprehensive system. Academically, this research is expected to make a theoretical contribution to the development of IoT-based learning media and to enrich the study of the relationship between learning interactivity, digital technology, and students' interest in learning.

## 2. METHODS

This study is a research and development (R&D) project aimed at producing and refining learning materials through systematic and scientifically rigorous procedures (Sari et al., 2022). The data types in this study are quantitative and qualitative, employing a one-group pre-test and post-test design, collected using an expert validation questionnaire, a student response questionnaire, and a learning interest questionnaire. The one-group pretest-posttest experimental design used in this study was implemented during the pilot phase within the R&D model framework to systematically evaluate the effectiveness of the product developed. The data were then analysed using a paired t-test, N-Gain, and descriptive statistics. The terminology used in data analysis has been standardised, including the paired t-test, N-gain, and descriptive statistics, to ensure consistency in the use of terms. Meanwhile, the product development procedure was adapted from the model stages proposed by Borg and Gall, implemented in stages from the preliminary study through to product testing to produce a valid, practical, and effective learning media product. As shown in Figure 1 below:

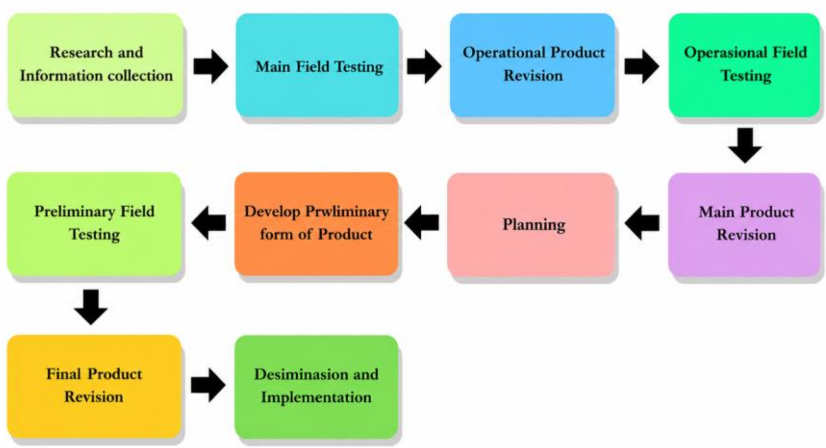



**Figure 1.** Development Model Flowchart (Borg and Gall)

The data used in this study comprises both quantitative and qualitative data, employing a one-group pretest-posttest design. The data was collected using an expert validation questionnaire, a student response questionnaire, and a learning interest questionnaire. The one-group pretest-posttest experimental design in this study was implemented during the large-scale field trial phase within the R&D model framework to systematically evaluate the effectiveness of the developed product. The data were then analysed using the paired t-test, N-Gain, and descriptive statistics. Terminology in the data analysis was standardised, including the paired sample t-test, N-gain, and descriptive statistics, to ensure consistency in the use of terms.

The subjects of the limited field trial consisted of 10 fourth-semester students, whilst the operational trial (large-scale) involved 20 second-semester students from the Primary School Teacher Education Programme at Muhammadiyah University of Mataram. The sampling technique used was purposive sampling, taking into account the suitability of the subjects' characteristics to the research requirements. The research subjects were active students who had taken the course 'Basic Concepts of Primary School Physics', making them suitable for the implementation of the developed product. The sample size in this study was determined based on the characteristics of the research and development, which focused on limited and operational trials to obtain data that met the criteria of validity, practicality, and effectiveness. The validation data obtained from media experts and subject matter experts were analysed by calculating the average assessment score for each validator using the following formula (Sari & Ratu, 2021):

$$\text{Final Mark} = \frac{\text{The score achieved}}{\text{maximum score}} \text{ X } 100 \quad (1)$$

Formulas are presented consistently to facilitate understanding of the calculation process. The 'IoT-Based Digital Measuring Instruments Training Kit' product, designed as an interactive learning tool to enhance students' interest in learning, has been deemed to meet the criteria for suitability or validity based on the results of validation tests conducted by experts. The assessment covered the substance of the material, the design of the media, and alignment with learning objectives. The quantitative data obtained was subsequently converted into suitability categories by referring to the assessment criteria as listed in Table 1 (Nizaar et al., 2021):

**Table 1.** Product Validity Criteria

| **Calculation** | **Criteria** |
|---|---|
| 80 <NV⩽ 100 | Highly Valid |
| 60 <NV⩽ 80 | Valid |
| 40 <NV⩽ 60 | Quite Valid |
| 20 <NV⩽ 40 | Not Valid |
| 0 <NV⩽ 20 | Invalid |

The table format is consistent to improve readability and ensure uniformity in the presentation of data. To interpret the data from the student response assessment, the student response criteria were used as a basis for analysis. The data obtained from the questionnaire was then converted into specific categories in accordance with established guidelines, thereby yielding a more objective and measurable interpretation. These criteria are presented in detail in Table 2 below:

**Table 2.** Student Response Criteria

| Score Interval | Practicality Criteria |
|---|---|
| $0 < P \leq 20$ | Not practical |
| $20 < P \leq 40$ | Not very practical |
| $40 < P \leq 60$ | Quite practical |
| $60 < P \leq 80$ | Practical |
| $80 < P \leq 100$ | Very practical |

The terms "student response" and "practicality" are used consistently throughout the analysis. The effectiveness of the product was analysed by comparing students' pre-test and post-test scores. The difference was tested using a paired sample t-test based on a one-group pre-test-post-test design to determine whether or not there was a significant difference before and after the use of the media. The extent of the increase in learning interest was analysed using the N-gain test to determine the level of increase that occurred in a quantitative and measurable manner. The formula is as follows (Kolengsusu, 2025):

$$g = \frac{(\%\text{on average})\text{-}(\%\text{on average})}{100\text{-}\%\text{average pre-test score}} \qquad (2)$$

The N-gain formula is presented in a systematic and consistent manner to facilitate the interpretation of the analysis results. The N-gain score categories are determined based on N-gain values converted into percentages. This classification is used to interpret the extent of improvement observed. The full breakdown of N-gain score categories is presented in Table 3 below (Kumalasari et al., 2023):

**Table 3.** N-gain criteria

| Score Ternormaliassi | Criteria Gain Increase |
|---|---|
| $g \geq 0{,}7$ | g-High |
| $0{,}7 > g \geq 0{,}3$ | g-Medium |
| $g < 0{,}3$ | g-Low |

The format and terminology in the table have been standardised to ensure consistency in the presentation of data and to make the research findings easier to read.

## 3. RESULT AND DISCUSSION

### 3.1 Data on Product Validity Test Results

This research and development project has resulted in a product in the form of an IoT-based digital measuring instrument training kit designed to enhance students' interest in learning; the step-by-step process followed in this research is adapted from the Barg & Gall model. The initial stage involved a field study, a pre-research activity aimed at collecting preliminary data through observation and interviews with colleagues to obtain information regarding the implementation of science education in the PGSD programme at UMMAT, where it was found that students' interest in learning remained low. This was evident in the ongoing learning process, which is essentially divided into two parts: theoretical and practical. In the course 'Basic Concepts of Primary School Physics', the achievement of learning objectives is highly dependent on practical experience. However, current practice still relies on conventional Student Worksheets (LKPD), without the support of digital tools. Consequently, students' interest in learning is low, which impacts their ability to understand concepts and achievement indicators, such as the skills required to use measuring instruments or understand measurement standards, meaning these have not yet been optimally achieved. These preliminary findings are not merely descriptive; rather, they suggest a link between the limitations of practical teaching resources and the low levels of cognitive and affective engagement among students in the learning process.

In the second phase, the researchers carried out planning activities, including content and conceptual analysis, the formulation of learning objectives, and the design of a prototype training kit and its user manual. Based on the results of the needs analysis conducted in the field, the researchers will develop a product in the form of an IoT-based digital measuring instrument training kit as a solution to address the issue of low student engagement in the learning process. The subsequent stages are the third and fourth stages, namely the development of a draft IoT-based digital measuring instrument training kit, followed by a validation stage carried out by validators to assess its suitability. The data from the product development validation are presented in Table 4.

**Table 4.** Expert Validation Results

| Name | Expert | Average Score | Criteria |
|---|---|---|---|
| Islahudin,M.Pd | Media Expert | 85,26% | Highly Valid |
| Linda Sekar Utami,MPd, | Subiect matter Expert | 84,62% | Highly Valid |
| | On average | 84,94% | Highly Valid |

Table 4 shows that the developed product received a 'highly valid' rating from the experts. Validation by media experts yielded an average score of 84.96%, indicating that all aspects met the established standards. The assessment by subject matter experts yielded an average score of 84.62%, reflecting the alignment of the content with the accuracy of the developed product. Based on the results of the assessments from the media and subject matter experts, an average percentage of 84.94% was obtained, classified as 'highly valid'. Consequently, it can be concluded that the IoT-based digital measuring instrument training kit meets the criteria for being 'highly valid' for use in learning. Analytically, these findings indicate that the integration of media design and content has met the principles of content and construct validity, meaning the product is deemed suitable for use as technology-based learning media. These results are consistent with the research by Cahaya et al. (2024) which emphasises that the validity of learning media is a key indicator in determining the success of product development. The fifth stage is the revision phase, which involves making improvements based on the suggestions and feedback from the validators to implement various corrections and refinements aimed at enhancing the quality of the product, as detailed in the revision results presented in Table 5 below:

Vol. 9, No. 2, August 2026, pp. 454-467

**Table 5.** Revised Data from the Validator

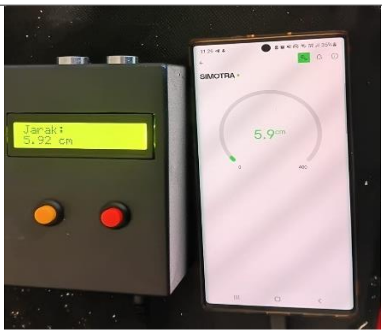
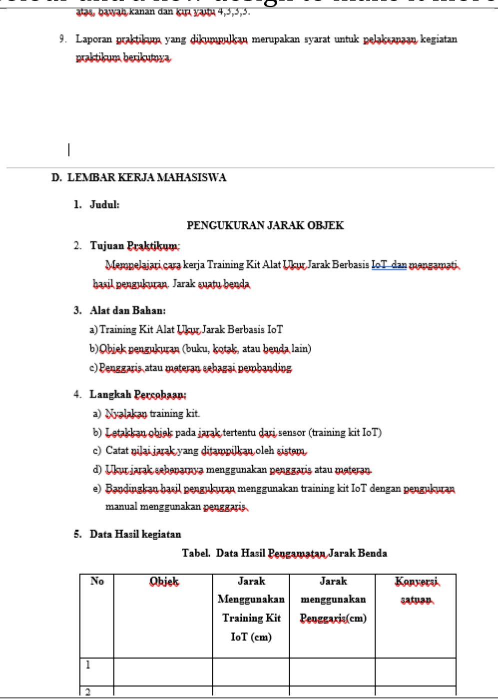
<table>
<tr><th colspan="2">IoT-Based Measuring Instrument Training Kit</th></tr>
<tr><th>Before</th><th>After</th></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">The On and Off buttons can be replaced with different colours on the IoT-based Measuring Instruments Training Kit to make it more appealing, and unit conversion can be added—not just centimetres (cm)</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">On the cover page, the font selection has been updated, with the image colours replaced by blocks of colour and a new design to make it more appealing</td></tr>
<tr><td colspan="2">
atas, bawah kanan dan kiri yaitu 4,3,3,3.<br>
9. Laporan praktikum yang dikumpulkan merupakan syarat untuk pelaksanaan kegiatan praktikum berikutnya.<br>
D. LEMBAR KERJA MAHASISWA<br>
1. Judul:<br>
PENGUKURAN JARAK OBJEK<br>
2. Tujuan Praktikum:<br>
Mempelajari cara kerja Training Kit Alat Ukur Jarak Berbasis IoT dan mengamati hasil pengukuran. Jarak suatu benda<br>
3. Alat dan Bahan:<br>
a) Training Kit Alat Ukur Jarak Berbasis IoT<br>
b) Objek pengukuran (buku, kotak, atau benda lain)<br>
c) Penggaris atau meteran sebagai pembanding<br>
4. Langkah Percobaan:<br>
a) Nyalakan training kit.<br>
b) Letakkan objek pada jarak tertentu dari sensor (training kit IoT)<br>
c) Catat nilai jarak yang ditampilkan oleh sistem.<br>
d) Ukur jarak sebenarnya menggunakan penggaris atau meteran.<br>
e) Bandingkan hasil pengukuran menggunakan training kit IoT dengan pengukuran manual menggunakan penggaris.<br>
5. Data Hasil kegiatan<br>
Tabel. Data Hasil Pengamatan Jarak Benda<br>
<table>
<tr><th>No</th><th>Objek</th><th>Jarak Menggunakan Training Kit IoT (cm)</th><th>Jarak menggunakan Penggaris(cm)</th><th>Konversi satuan</th></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td colspan="2">The training kit handbook provides examples of practical activities, but these can be further developed for other sensors and other types of measurement</td></tr>
</table>

Table 5 above shows that the IoT-based digital measuring instrument training kit requires improvements in several areas based on the feedback received. Firstly, the On and Off buttons could be replaced with different colours on the IoT-based digital measuring instrument training kit, and unit conversion could be added—not just centimetres—to make it more appealing. Secondly, regarding the cover design, the font type and image colours should be changed to a block style, with different colours and image designs to make it more appealing. Thirdly, whilst the training kit manual already provides examples of practical activities, these could be further developed to include other sensors and types of measurement. These improvements demonstrate that aesthetics, functionality and the comprehensiveness of content play a significant role in comprehensively enhancing the quality of learning materials. Following product validation, the process proceeded to the sixth stage: a usability test conducted on a limited sample of 10 fourth-semester PGSD students to assess the usability of the developed product. The usability data for the IoT-based digital measuring instrument training kit is presented in Table 6 below:

**Table 6.** Product Usability Results

| Aspect | Indicator | Average Student Response | Criteria |
|---|---|---|---|
| Suitability of Content (Educational) | 1 | 3,8 | Practical |
| | 2 | 3,8 | Practical |
| | 3 | 4 | Practical |
| | 4 | 3,8 | Practical |
| | 5 | 3,5 | Practical |
| | 6 | 3,4 | Practical |
| | 7 | 3,2 | Practical |
| | 8 | 3,7 | Practical |
| | 9 | 3,4 | Practical |
| Appearance (Product Aesthetics) | 10 | 3,4 | Practical |
| | 11 | 3,6 | Practical |
| | 12 | 3,6 | Practical |
| | 13 | 3,4 | Practical |
| | 14 | 4,3 | Very Practical |
| | 15 | 3,6 | Practical |
| | 16 | 3,4 | Practical |
| Technical and Practical Aspects of the Product | 17 | 3,3 | Practical |
| | 18 | 3,8 | Practical |
| | 19 | 3,9 | Practical |
| | 20 | 3,3 | Practical |
| | 21 | 3,8 | Practical |
| | Total | 3,62 | Practical |
| | On average | 3,62 | |
| | % | 72,4 | |

Table 6 shows that the results of the analysis of responses from fourth-semester PGSD students regarding the practicality of the IoT-based digital measuring instrument training kit indicate that the product falls into the 'practical' category, with an overall average score of 3.62 and a practicality percentage of 72.4%, which falls within the range $60 < P \leqslant 80$. In terms of the suitability of the material (educational), all indicators were classified as practical with a score range between 3.2 and 4.0, indicating that the material presented was relevant to the learning outcomes and supported students' conceptual understanding. It can therefore be understood that the IoT-based digital measuring instrument training kit product has met the practicality criteria and can be used on a wider scale, namely by third-semester PGSD students. Analytically, this level of practicality indicates that the product is not only easy to use but also capable of facilitating more effective learning interactions, which is one of the indicators of the success of interactive learning media. This is in line with Putra et al. (2026) research, which suggests that technology-based interactive learning media contribute to increasing learners' active engagement and encourage the formation of more meaningful learning experiences through the integration of visual elements, hands-on practice, and participation in the learning process.

The seventh stage involves revisions to refine the product based on the results of the practical trials. As there are no revisions at this stage, only technical improvements to the delivery of the learning process in the form of using the IoT-based digital measuring instrument training kit—with at least one kit provided to each group to ensure all students have an equal opportunity to use the IoT-based digital measuring instrument training kit—and the time allocated for the practical session has been reduced from the initial 20 minutes to just 10–15 minutes to allow for more effective discussion.

The next stage, namely the eighth stage, is an operational/empirical field trial. This aims to test the feasibility and effectiveness of using the IoT-based digital measuring instrument training kit in enhancing the learning motivation of PGSD UMMAT students. To measure the increase in students' learning motivation, the researcher used a motivation questionnaire administered to 20 students. To analyse the data on the increase in students' learning interest obtained through the questionnaire, the test was conducted using the pre- and post-questionnaire scores via a one-group pre-test-post-test design, employing a paired-sample t-test to determine the effect on students' learning interest following the use of the IoT-based digital measuring instrument training kit, as presented in Table 7 below:

**Table 7.** Paired Samples T-Test

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | Pre Angket - Post Angket | -33.10000 | 3.83749 | .85809 | -34.89600 | 31.30400 | -38.574 | 19 | .000 |

Table 7 shows the results of the analysis using a paired-sample t-test, which yielded a significance value (Sig., two-tailed) of 0.000, which is smaller than the significance level of 0.05. These results indicate that there is a significant difference between learning interest prior to the intervention involving the use of the IoT-based digital measuring instrument training kit and learning interest following the intervention involving the use of the IoT-based digital measuring instrument training kit. The mean difference of -33.10 indicates a difference in the average between the two measurements, where the post-questionnaire score was higher than the pre-questionnaire score. The analysis results show that there was a change in scores between the measurements before and after the intervention. These findings suggest that the use of IoT-based media has a significant impact on increasing students' interest in learning, which can theoretically be explained by enhanced interactivity and practice-based learning experiences. To determine the percentage increase in students' interest in learning, the researchers proceeded to conduct an N-Gain test, the results of which are presented in Table 8 below:

**Table 8.** Summary of Interest Gain Scores Before and After Using an IoT-Based Measurement Tool

| No | Name | Initial Interest | Final Interest | Gain |
|---|---|---|---|---|
| 1 | AAA | 39 | 72 | 0,54 |
| 2 | AJA | 38 | 74 | 0,58 |
| 3 | ADP | 40 | 76 | 0,60 |
| 4 | AST | 39 | 73 | 0,56 |
| 5 | ANR | 46 | 70 | 0,44 |
| 6 | ARPI | 39 | 70 | 0,51 |
| 7 | AAS | 40 | 70 | 0,50 |
| 8 | BAZ | 39 | 70 | 0,51 |
| 9 | BTR | 48 | 73 | 0,48 |
| 10 | DAS | 37 | 75 | 0,60 |
| 11 | DKI | 36 | 73 | 0,58 |
| 12 | DT | 37 | 76 | 0,62 |
| 13 | FNH | 39 | 72 | 0,54 |
| 14 | GAN | 39 | 70 | 0,51 |
| 15 | GWR | 39 | 72 | 0,54 |
| 16 | MDR | 39 | 75 | 0,59 |
| 17 | MCC | 38 | 70 | 0,52 |
| 18 | NDP | 38 | 71 | 0,53 |
| 19 | RA | 38 | 73 | 0,56 |
| 20 | RANF | 37 | 72 | 0,56 |
| On average | | 39,25 | 72,35 | 0,54 |
| Score Gain | | | 0,54 | |
| Category | | | Medium | |

Table 8 shows that the average score increased from 39.25 at the start to 72.35 at the end, with an average gain of 0.54. This indicates that the learning interest of all students increased after using the IoT-based Measurement Tools Training Kit. Individual gains ranged from 0.44 to 0.62, which, based on the interpretation criteria, falls within the moderate category. Analytically, this 'moderate improvement' category indicates that, whilst the product is effective in boosting interest in learning, there is still scope for further development to optimise its impact on learning. This finding is consistent with the research by (Machmud et al., 2025), which states that the integration of IoT into teaching can enhance student engagement through learning experiences based on real-time data.

### 3.2 Discussion

The results of the research and development indicate that the Internet of Things (IoT)-based digital measuring instrument Training KIT developed has met the product feasibility criteria based on the validity test results conducted by experts. Based on the data in Table 4, the assessment by media experts yielded an average score of 85.26%, whilst the assessment by content experts reached 84.62%. Both results fall within the 'highly valid' category, indicating that the aspects of media design, presentation, and the suitability of the learning materials have met

Vol. 9, No. 2, August 2026, pp. 454-467

the standards for good educational media development. Overall, the product achieved an average score of 84.94%, falling into the 'highly valid' category. These findings indicate that the training kit developed possesses a high level of suitability for use in learning activities. Nevertheless, several improvements were implemented based on feedback from the validators to refine the product's quality and enhance the optimisation of the media's functions within the learning process. More broadly, these findings reinforce the notion that the validity of technology-based learning materials is a key prerequisite for effective, high-quality learning.

The results of the practicality test indicate that the developed product offers a good level of user-friendliness for students. Based on the data in Table 6, the average score for student responses regarding the product's practicality was 3.62, with a percentage of 72.4%, which falls within the 'practical' category. Regarding the educational content, all indicators scored within the 'practical' category, with scores ranging from 3.2 to 4.0. This indicates that the material presented in the training kit is relevant to the learning outcomes and effectively supports students' conceptual understanding. Consequently, the product is not only theoretically sound, but also easy to use effectively in teaching practice.

The next stage of testing focused on analysing the product's effectiveness in increasing students' interest in learning through a paired-sample t-test. Based on the results of the analysis presented in Table 7, a significance value of Sig. (2-tailed) of 0.000 was obtained, which is smaller than the significance level of 0.05. The results indicate that there is a significant difference in learning motivation before and after the use of the IoT-based digital measuring instrument training kit. The mean difference of -33.10 indicates a difference in the average scores between the two measurements, with the post-questionnaire scores being higher than those of the pre-questionnaire. It can therefore be concluded that the use of the IoT-based digital measuring instrument training kit effectively enhances students' learning interest during the learning process. Conceptually, this improvement suggests that the integration of IoT technology is capable of creating a more interactive and meaningful learning experience, thereby having a positive impact on students' affective aspects.

The extent of the increase in students' interest in learning is evident from the results of calculations using N-Gain analysis, which show an increase in interest scores before and after the use of the product. Based on the data in Table 8, the average interest score of students increased from 39.25 at the start to 72.35 at the end, with an average increase of 0.54, which falls into the moderate category. Individual increases ranged from 0.44 to 0.62, indicating that almost all students experienced an increase in learning interest after using the IoT-based training kit. These findings suggest that the integration of IoT technology into learning media not only supports more interactive practical activities but also contributes to enhancing students' interest and engagement in the learning process more effectively. The research results provide empirical evidence regarding the effectiveness of using IoT-based training kits in the context of practical learning in higher education.

## 4. CONCLUSION

The research findings confirm that the IoT-based Digital Measuring Instruments Training Kit developed meets the standards of suitability in terms of content, design and usability. Validation by media and subject matter experts yielded an average score of 84.94%, categorised as 'highly suitable', indicating that the product aligns with the learning outcomes, demonstrates conceptual accuracy, and is supported by an adequate interface and interactive system. In terms of implementation, student responses regarding the practicality of the media yielded an average score of 3.62, with 72.4% falling into the 'practical' category. These findings indicate that the media is easy to operate, communicative, and capable of supporting the learning process effectively and efficiently during practical sessions. This study contributes academically by presenting empirical findings that demonstrate the effectiveness of IoT-based learning media in improving the quality of practical learning, while practically providing an alternative interactive instructional tool to support measurement-based learning activities in higher education.

An analysis of effectiveness revealed a significant increase in learning interest following the use of the media, as demonstrated by the results of a paired-sample t-test with a significance value of 0.000 ($p < 0.05$). These results were reinforced by the N-gain analysis, which yielded an average of 0.54 in the moderate category, with consistent improvements observed across all students. The integration of IoT technology into learning materials has been shown to significantly increase active engagement and enhance students' ability to use IoT-based digital measuring instruments in practical learning activities, whilst also aiding their understanding of measurement concepts. This demonstrates that the use of modern measuring instruments is effective in boosting the learning interest of Primary School Teacher Education (PGSD) students. It is hoped that the IoT-based digital measuring instrument training kit will serve as a reference for the innovative and effective use of technology in supporting practical-based learning. Further research is recommended to review, refine and further adapt the accuracy and relevance of the implementation of learning, as the use of these IoT-based digital measuring instruments depends on the availability of a stable Wi-Fi connection for SIMOTRA (Smart IoT Measurement Trainer) and requires students to download the supporting Blind application in advance to avoid problems when the learning takes place. Furthermore, future research is recommended to involve a larger and more heterogeneous sample and to explore other measurement concepts as well as broader impacts, such as learning outcomes in the form of higher-order thinking skills.

## ACKNOWLEDGEMENT

As the researcher, I would like to express my deepest gratitude and appreciation, particularly to the RisetMu Programme as the primary funding body, for providing substantial support throughout the implementation and completion of this research. I would also like to thank the leadership of the Faculty of Teacher Training and Education (FKIP) at Muhammadiyah University of Mataram for their support and guidance throughout the research process.

## REFERENCES

Ali, A., Fenica, S. D., Aini, W., & Hidayat, A. F. (2025). Efektivitas Media Pembelajaran Interaktif dalam Meningkatkan Minat dan Motivasi Belajar Siswa Sekolah Dasar. *JISED; Journal of Information System and Education*, *3*(1), 1–6. https://doi.org/https://doi.org/10.62386/jised.v3i1.115

Badshah, A., Ghani, A., Daud, A., Jalal, A., Bilal, M., & Crowcroft, J. (2023). Towards Smart Education through Internet of Things: A Survey. *ACM Computing Surveys*, *56*(2), 1–33. https://doi.org/10.1145/3610401

Barashkin, R., Nurguatova, A., Kalashnikov, P., Taktasheva, D., & Tupysev, A. (2023). Enhancement of efficiency of the training process with the use of digital technologies. *Education for Chemical Engineers*, *45*, 104–121. https://doi.org/10.1016/j.ece.2023.08.005

Burke, K., Fanshawe, M., & Tualaulelei, E. (2021). We can't always measure what matters: revealing opportunities to enhance online student engagement through pedagogical care. *Journal of Further and Higher Education*, 46(3), 287–300. https://doi.org/10.1080/0309877X.2021.1909712

Cahaya, N., Fauziah, N., Ferazona, S., Hidayati, N., Mellisa, & Yeyendra. (2024). Lembar Praktikalitas: Instrumen yang Digunakan untuk Menilai Produk yang Dikembangkan pada Penelitian Pengembangan Bidang Pendidikan. *Biology and Education Journal*, *4*(1), 48–68. https://journal.uir.ac.id/index.php/baej/article/view/16973/6564

Ghashim, I. A., & Arshad, M. (2023). Internet of Things (IoT)-Based Teaching and Learning: Modern Trends and Open Challenges. *Sustainability*, *15*(21), 15656. https://doi.org/10.3390/su152115656

Gulati, K., Boddu, R. S. K., Kapila, D., Bangare, S. L., Chandnani, N., & Saravanan, G. (2022). A review paper on wireless sensor network techniques in Internet of Things (IoT). *Materials Today: Proceedings*, *51*(Part 1), 161–165. https://doi.org/10.1016/j.matpr.2021.05.067

Halawa, M. (2024). The Influence of Information and Communication Technology-Based Learning Media on Enhancing Students' Learning Motivation. *JPVI: Jurnal Pendidikan Vokasi Indonesia*, *3*(1), 13–18. https://jurnal.mifandimandiri.com/index.php/jpvi

Hartono, H., Ningsi, N., & Hina, S. (2025). Developing interactive learning media to enhance elementary school students' learning motivation. *EDUCARE: Journal of Primary Education*, *6*(1), 81–96. https://doi.org/10.35719/educare.v6i1.291

Kolengsusu, H. (2025). Efektivitas Media Edpuzzle Dalam Meningkatkan Minat Belajar Peserta Didik SMA Negeri 62 Maluku Tengah. *Kuantum: Jurnal Pembelaran Dan Sains Fisika*, *6*(2), 356–371. https://doi.org/10.63976/kuantum.v6i2.1226

Krutgeen, S., & Hinon, K. (2025). Development of a practical training kit for household electrical and lighting circuits to promote problem-solving skills in electrical and electronics work for vocational certificate students. *Journal of Industrial Education*, *24*(2), 122–135. https://doi.org/10.55003/JIE.24216

Kumalasari, N., Fathurohman, I., & Fakhriyah, F. (2023). Pengembangan E-Modul Berbasis Kearifan Lokal Daerah Grobogan untuk Meningkatkan Hasil Belajar Siswa Sekolah Dasar. *Jurnal Paedagogy: Jurnal Penelitian Dan Pengembangan Pendidikan*, *10*(2), 554–563. https://doi.org/10.33394/jp.v10i2.7190

Li, Y., Chen, D., & Deng, X. (2024). The impact of digital educational games on student's motivation for learning: The mediating effect of learning engagement and the moderating effect of the digital environment. *PLoS ONE*, *19*(1), 1-21. https://doi.org/10.1371/journal.pone.0294350

Machmud, P., Gunawan, A., Purwanto, A., & Saputra, H. (2025). Peningkatan Hasil Belajar Mahasiswa Melalui Integrasi IoT dalam Pembelajaran Berbasis Pengalaman pada Pendidikan Tinggi. *Jurnal Pengabdian Masyarakat Dan Riset Pendidikan*, *3*(4), 2337–2343. https://doi.org/10.31004/jerkin.v3i4.890

Mahmood, A. F., Ahmed, K. A., & Mahmood, H. A. (2022). Design and implementation of a microcontroller training kit for blend learning. *Computer Applications in Engineering Education*, *30*(4), 1236–1247. https://doi.org/10.1002/cae.22517

Nizaar, M., Haifaturrahmah, Abdillah, Sari, N., & Sirajuddin. (2021). Pengembangan Modul Tematik Berbasis Model Direct Instruction dalam Meningkatkan Hasil Belajar Siswa di Sekolah Dasar. *Jurnal Basicedu*, *5*(6), 6150–6157. https://doi.org/10.31004/basicedu.v5i6.1792

Nurhikmah, H., Ramli, A. M., Sujarwo, Bena, B. A., Arwadi, F., Syawaluddin, A., & MalikNur, I. D. (2024). Teachers' Readiness in Online Learning: Digital Literacy-Self-Efficacy, Pedagogical Competence, Attitude, Infrastructure, and Management Support. *Electronic Journal of E-Learning*, *22*(8), 94. https://doi.org/10.34190/ejel.22.8.3358

Purwanto, M. B., Hartono, R., & Wahyuni, S. (2023). Essential Skills Challenges for the 21st Century Graduates: Creating A Generation of High-Level Competence in The Industrial Revolution 4.0 Era. *Asian Journal of Applied Education (AJAE)*, *2*(3), 279–292. https://doi.org/10.55927/ajae.v2i3.3972

Putra, M. I. Z., Mujiwati, Y., & Ali, M. H. (2026). Media Pembelajaran Interaktif dalam Upaya Mendorong Pembelajaran Berpusat pada Siswa di SMA. *Jurnal Media Pembelajaran*, *11*(1), 280–288. https://doi.org/10.34125/jmp.v11i1.1524

Sabri, S. M., Ismail, I., Annuar, N., Rahman, N. R. A., Hamid, N. Z. A., & Mutalib, H. A. (2024). A Conceptual Analysis of Technology Integration in Classroom Instruction Towards Enhancing Student Engagement and Learning Outcomes. *International Journal of Education, Psychology and Counseling*, *9*(55), 750–769. https://doi.org/10.35631/IJEPC.955051

Sari, N., Haifaturrahmah, Ratu, T., Widiartini, N. N., & Erfan, M. (2022). Pengembangan LKS Interaktif Science Live Worksheet Berbasis HOTS Siswa Sekolah Dasar. *Paedagoria: Jurnal Kajian, Penelitian Dan Pengembangan Kependidikan*, *13*(2), 118–123. https://doi.org/10.31764/paedagoria.v13i2

Sari, N., & Ratu, T. (2021). Pengembangan Media Komik Bermuatan IPA Berbasis Model Inkuiri Terbimbing dalam Meningkatkan Motivasi Siswa Sekolah Dasar. *Jurnal Basicedu*, *5*(6), 6185–6195. https://doi.org/https://doi.org/10.31004/basicedu.v5i6.1793TY

Shenkoya, T., & Kim, E. (2023). Sustainability in Higher Education: Digital Transformation of the Fourth Industrial Revolution and Its Impact on Open Knowledge. *Sustainability*, *15*(3), 2473. https://doi.org/10.3390/su15032473

Sitorus, L. S., Sipahutar, M. I., Nasution, S. N., Purnama, L., & Iskandar, T. (2025). Literature Review on the Use of Technology-Based Learning Media in the Context of Distance Learning. *Jurnal Medika: Medika*, *4*(3), 283–289. https://doi.org/: https://doi.org/10.31004/bkxg7355

Soghomonyan, Z., & Karapetyan, A. (2023). Teaching Strategies of the 21st Century Skills Adapted to the Local Needs. *European Journal of Teaching and Education*, *5*(3), 48–69. https://doi.org/10.33422/ejte.v5i3.1097

Tariq, R., Munoz, F. A. C., Hassan, S. tauseef, & Montoya, M. S. R. (2024). Synergy of Internet of Things and Education: Cyber-physical Systems contributing towards Remote Laboratories, Improved Learning, and School Management. *Journal of Social Studies Education Reseacrh*, *15*(2), 305–352. https://www.learntechlib.org/p/224826/

Zeeshan, K., Hämäläinen, T., & Neittaanmäki, P. (2022). Internet of Things for Sustainable Smart Education: An Overview. *Sustainability*, *14*(7), 4293. https://doi.org/10.3390/su14074293