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Development and Validity Analysis of an ESP8266-Based IoT Training Kit for Vocational School Students

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Abstract
The transformation of vocational education, especially vocational high schools (SMK), towards Industry 4.0 requires learning media in the field of IoT that are affordable, applicable, and aligned with the curriculum. This study aims to develop and analyze the validity of an ESP8266-based IoT training kit for vocational school students. Using the Borg & Gall Research and Development model, the stages include needs analysis through practical observations and teacher interviews, design and prototype creation, and expert validation. Three validators (experts in learning media, vocational education learning, and one vocational school teacher in the field of electronics) assessed the kit using a Likert scale of 1-4 with a calculation of the percentage of achievement. The results showed an average validity of 98%, so the product is classified as very valid and suitable for use as a learning medium. Theoretically, this study strengthens research on the development of IoT media in vocational education. On the other hand, practically, the resulting training device is very economical, simple, compatible with various sensors/actuators, and facilitates students' application skills through direct practice. The implication is that this training tool is ready to be integrated into practical sessions to support the achievement of IoT competencies and job readiness.

Keywords
ESP8266; vocational education; vocational high school; training kit IoT

INTRODUCTION

Digital transformation in the Industry 4.0 era requires the integration of Internet of Things (IoT) technology in various sectors, including in learning in vocational education, especially Vocational High Schools (VHS), in order to prepare graduates in accordance with the demands of the modern world of work (Spöttl & Windelband, 2021; Putri et al.

2025; Syarif & Janata, 2024). The global growth of Internet of Things (IoT) devices is projected to almost triple, rising from 13.8 billion units in 2022 to more than 40 billion by 2034 (Statista, 2025). Among these, the ESP8266 microcontroller stands out as one of the most widely used devices due to its affordability, accessibility, and high flexibility in supporting IoT-based applications and learning (Habibi & Buditjahjanto, 2024). Within the educational context, the demand for practical and applicable learning media has become increasingly important. Students are expected not only to master theoretical knowledge but also to build real-world skills through hands-on experiences. One effective approach to achieving this is through the development of IoT training kits, which bridge classroom learning with direct practice and skill application (Nyström & Ahn, 2024).

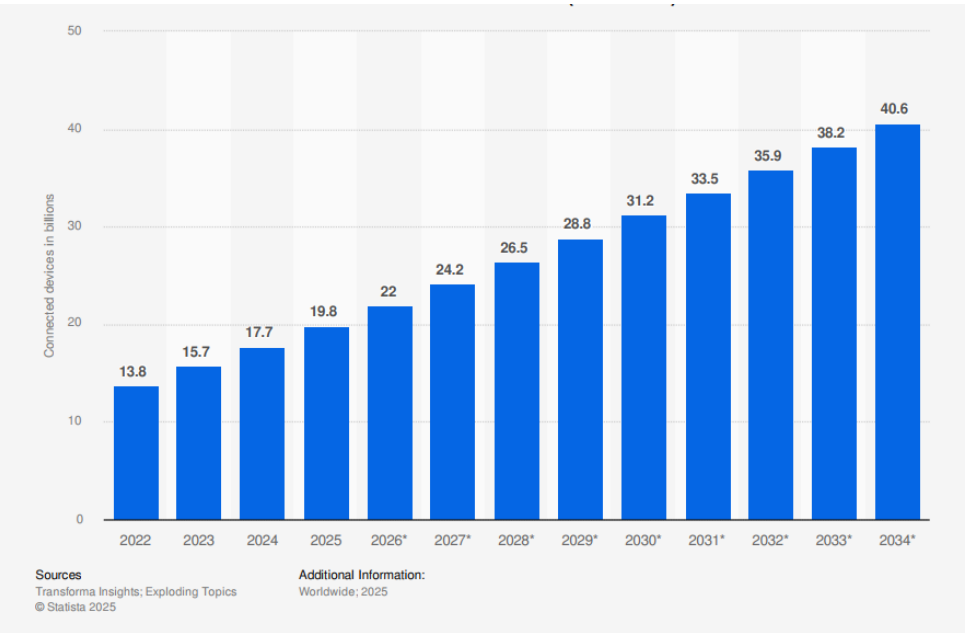

Figure 1. Internet of Things (IoT) users in the world

The reality in the field shows that Internet of Things (IoT) learning in vocational schools is still dominated by theoretical approaches, simulations, or the use of relatively complex and expensive devices (Candra et al., 2025; Aryanta & Dewanto, 2024; Suwastika et al., 2025). The limitations of contextual, affordable, and relevant practical media to students' needs cause students to find it difficult to connect theoretical concepts with real applications. This condition is exacerbated by the limitations of teachers in providing teaching tools that are in line with the vocational curriculum and relevant to industry standards (Esmail & Khan, 2024). As a result, the latest study revealed that the mastery of IoT competencies of vocational school students is still at a relatively low level, thus

hindering the achievement of vocational education goals in preparing a workforce that is adaptive to technological developments (Khairunnisa et al., 2025).

Various previous studies have attempted to design training kits based on Arduino, Raspberry Pi, and other IoT modules as a means to improve the skills of students in vocational education, especially vocational schools (Nannim et al., 2025; Sukir et al., 2025). These findings show that the use of training kits can encourage learning motivation, strengthen practical skills, and deepen concept understanding. However, most of the devices developed still have relatively high procurement costs, making them less suitable for the context of vocational education, especially vocational schools (Brasoveanu et al., 2020). In its development, ESP8266 is starting to be widely used as an alternative because it supports Wi-Fi connectivity, is easy to program, and is compatible with various sensors and actuators at low cost, so it has the potential to be a more efficient and applicable solution in learning and developing student competencies in the field of IoT.

Although research on IoT learning media has been extensive, studies that specifically highlight the validity of ESP8266-based IoT training kits in the context of VHS are still very limited. In fact, validity analysis is a crucial aspect because it determines the extent to which the learning media is effective, feasible, and appropriate to support the achievement of vocational student competencies. This research gap shows that there is an urgent need to present tools that are not only pedagogically relevant, but also practical and affordable for the vocational school environment. Therefore, this study offers a solution through the development and analysis of the validity of ESP8266-based IoT training kits designed according to the needs of vocational school students, so that they are able to function as a means of learning that is applicable, economical, and in line with the demands of technological developments.

This study aims to analyze the validity of IoT-based training kits using ESP 8266 microcontrollers. In particular, this research focuses on two main objectives, namely: (1) developing a ESP8266-based IoT training kit design that is in accordance with the needs of vocational learning, especially vocational schools; and (2) evaluate its validity through the study of experts in the field of learning and learning media of vocational education. The resulting contributions include strengthening theoretical aspects through the study of the development of IoT media in vocational education, as well as practical contributions in the form of training kit products that can be used by teachers and students directly. The

advantage of this training kit lies in its more affordable, simple, relevant to the curriculum, and supporting the IoT practice skills of vocational school students in an applicative manner.

METHOD

This research method describes the data collection procedures, data sources, and analysis techniques applied. This research approach is experimental and preceded by a review of previous research placed before the methodology chapter to provide a theoretical foundation and support innovation in research and development (R&D). The result of this study is the development of a ESP8266-based IoT Training Training-Kit whose validity has been tested and declared suitable for use as a learning medium for vocational school students. In general, research and development (R&D) is a method that aims to produce a certain product while testing the validity of the product (Okpatrioka, 2023). This development research model refers to Borg & Gall where this research model is considered suitable for developing learning tools (Husnayayin et al., 2024). The development research steps to be carried out can be seen in figure 2.

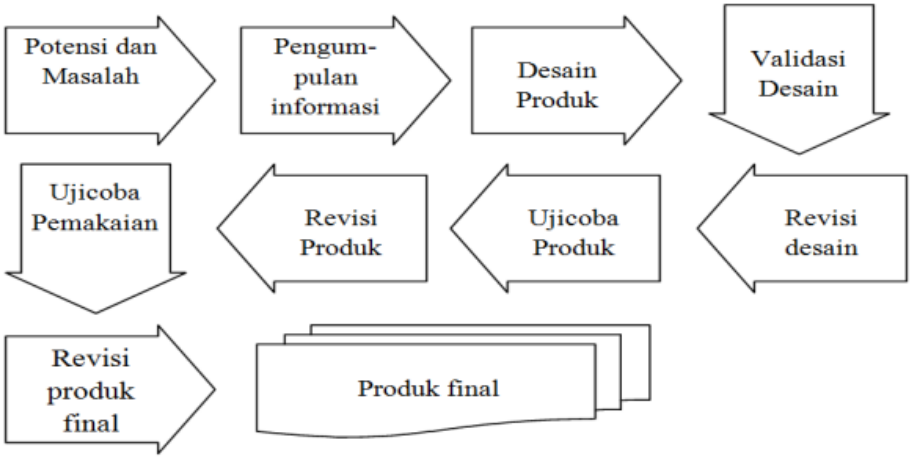

Figure 2. Borg & Gall's R&D steps

In this study, titled Development and Analysis of the Validity of ESP8266-Based IoT Training Kits for Vocational School Students, identifying the lack of subject-specific learning media that hinder learning achievement through practicum observation and teacher interviews, this study obtained learning objectives and practicums that guide the design and validation of the kit.

The development process of ESP8266-based IoT Training Kits includes the stages of product design, identification of required components, and the selection of tools and materials needed for its manufacture. The final Training Kit must conform to the predetermined design specifications. To evaluate its quality, validation instruments are prepared and used. Product validation is carried out through expert testing and review by designated validators. This validator provides assessments and recommendations related to the feasibility of the product as a learning medium in vocational schools. If the Training Kit does not meet the required standards, revisions must be made until the validator declares its validity (Syaiful, 2025).

Training-Kit validity analysis technique as a valid assessment of the developed product. Based on the results of the validity values obtained, they are then categorized according to the level of validity with a Likert scale of 1-4 in Table 1.

Table 1. Kategori Validasi Training-Kit

Presentation of Achievements	Value Scale	Interpretasi
81% ≤ score ≤ 100%	4	Highly Valid
61% ≤ score ≤ 80%	3	Valid
41% ≤ score ≤ 60%	2	Less Valid
0% ≤ score ≤ 40%	1	Invalid

To calculate the percentage of responses use the following formula:

$$\text{Score Total}(\%) = \frac{\text{Total scores obtained}}{\text{Max score x number of validators}} \times 100\%$$

RESULT AND DISCUSSION

This research focuses on the development of ESP8266-based IoT Training Training-Kits for vocational school students, judging from the lack of learning media that hinders the learning process and learning achievement through the practicum observation stage and teacher interviews, from these results can be the learning objectives and practicum that guides the creation of Training-Kit designs in learning media. Furthermore, the planning phase includes the creation of Training-Kit products, including material planning in accordance with the needs analysis included in the learning media in the form of ESP8266-based IoT Training Training-Kits. The next phase is the design of the Traininig-Kit, which must be in accordance with the material, specifications, and design of the product that has

been planned. The next stage of development is with the aim of creating a learning media product in the form of a Training-Kit that has been validated by the validator and declared very valid to be used in the learning process. The following are the results of the products developed in the form of ESP8266-based IoT training teaching aids (Training-Kits) shown in Figure 3.

Figure 3. ESP8266-Based IoT training kit design

The second stage is a product validity test in the form of Training-Kits that have been designed and made. The Training-Kit is validated before being used in the learning process. This validation was carried out by the three validators who have expertise in the field of ESP8266-based IoT media and learning materials. The results of the calculation of Training-Kit validation in percentage based on the formula above can be seen in Figure 4.

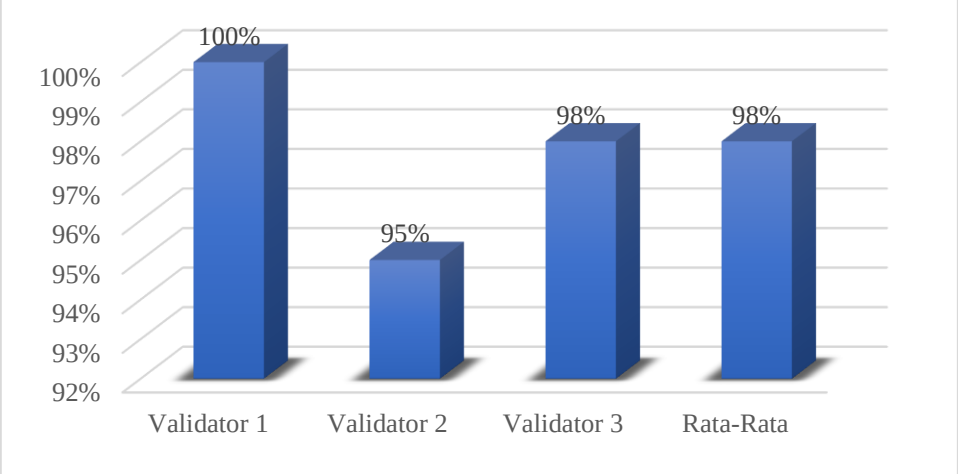

Figure 4. Results of the calculation of the validity test of ESP8266 based IoT training-kit

Based on Figure 3, an explanation can be drawn where from the results of product testing (validity) an average percentage of 98% was obtained, so that the products developed by the ESP8266-Based IoT Training-Kit are categorized as Very Valid for use in the learning process of students in vocational schools.

CONCLUSION

The study developed a ESP8266-based IoT Training Training-Kit using Research and Development (R&D) research methods based on Borg & Gall's development, which includes the planning, design, manufacturing, and validation stages. Validation was carried out by three experts in Learning, Vocational Education Learning, and one of the vocational school teachers in the field of electronics using a Likert scale of 1-4 and a percentage score, resulting in an average validity score of 98%. Therefore, this kit is classified as Highly Valid and is considered appropriate as a practical learning resource for vocational high school students. It is recommended that this kit be used in practicum sessions to evaluate its effect on students' practical competencies, accompanied by user manuals and worksheets for ease of implementation, as well as undergo additional field trials to test its usability and durability in real classroom conditions.

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