PUBLISHER
YAYASAN PENDIDIKAN DAN PENGEMBANGAN HARAPAN ANANDA

JURNAL
WAWASAN DAN AKSARA

Juwara | p-issn: 2797-2097 | e-issn: 2797-2119 | **Vol. 5 No. 1 (2025)**
https://doi.org/10.58740/juwara.v5i1.497

Development of Logic Gate Trainer Kit Media: Validity Study

M. Syaiful[1(✉)]
[1]Akademi Komunitas Industri Pertambangan Bukit Asam, Indonesia

✉Correspondence Author: m.syaiful@akipba.ac.id

Abstract
This study aims to develop a Logic Gate Trainer Kit as an effective instructional medium and to evaluate its validity through expert assessment. The development process adopts the Instructional Development Institute (IDI) model, which consists of three stages: define, develop, and evaluate. During the define phase, instructional needs and media specifications were identified. In the develop phase, a prototype of the trainer kit was created based on the instructional objectives and technical requirements. The evaluate phase involved expert validation to assess the media's quality and relevance. A total of four media experts and four subject matter experts participated in the validation process. The results of the media expert validation yielded an average score of 0.78 %, exceeding the minimum validity threshold of 0.667 %, indicating that the media is valid. Similarly, the validation by subject matter experts produced an average score of 0.82%, confirming the content validity of the trainer kit. These findings demonstrate that the Logic Gate Trainer Kit is a valid learning medium and suitable for use in digital electronics instruction.

Keywords
idi model; instructional media; logic gate; trainer kit

INTRODUCTION

The accelerating pace of technological innovation in the 21st century has significantly influenced educational paradigms, particularly in the fields of science, technology, engineering, and mathematics (STEM). In this context, technical and vocational education is increasingly expected to not only transmit theoretical knowledge but also to cultivate students' ability to apply concepts through practical and problem-based learning (Mustakim, W., et al. 2024). One critical component of digital electronics instruction is the understanding of logic gates, which serve as the foundational elements in the design and operation of digital circuits and systems. Logic gates are not only abstract in nature but also fundamental to more complex digital operations, including arithmetic logic units, memory systems, and microprocessors (Widinata, F., et al. 2025).

Despite the foundational role of logic gates in digital electronics, many students struggle to comprehend their structure, function, and application when instruction relies solely on conventional didactic methods or abstract simulations (Kholis, N., et al. 2025). The gap between conceptual understanding and practical competence remains a persistent challenge in electronics education. Moreover, the absence of interactive, hands-on learning tools in many educational institutions exacerbates this challenge, often resulting in superficial understanding and limited skill acquisition among students (Gao, K., et al. 2024). Therefore, there is an urgent pedagogical need for instructional innovations that can bridge the cognitive gap between theory and practice (Fuada, S. 2022).

Physical instructional media, such as trainer kits, have been shown to offer considerable pedagogical advantages in technical education. Trainer kits enable students to engage in direct manipulation of electronic components, observe immediate responses to their inputs, and develop an intuitive understanding of how logic circuit’s function (Qi, S., et al. 2022). Such experiential learning approaches are consistent with constructivist learning theory, which posits that learners construct knowledge more effectively when they actively engage with content in meaningful contexts (Owolabi, A. O., et al. 2024). Moreover, prior empirical studies have demonstrated that the use of trainer kits can enhance students’ motivation, learning retention, and problem-solving skills, particularly in technical and engineering disciplines (Li, Y., et al. 2021).

Nevertheless, the development of effective instructional media must be grounded in systematic design principles and supported by empirical validation. Instructional tools that are not rigorously validated may fail to meet learning objectives or could even mislead students in their understanding of core concepts. This underscores the importance of conducting validity studies as part of any educational media development process. Validation not only ensures alignment with curricular goals and learner needs but also provides evidence of the tool’s instructional soundness and usability in educational settings (Yanie, A. 2024).

Given these considerations, this study seeks to address the instructional gap in digital electronics education by developing and validating a physical instructional medium in the form of a Logic Gate Trainer Kit (Kohpeisansukwattana, N., et al. 2024). The trainer kit is designed to serve as a practical learning aid that supports students' conceptual and procedural understanding of logic gates (Petersen, F., et al. 2024). Through a rigorous validation process involving subject matter and media experts, this study aims to determine the degree to which the developed trainer kit meets standards of content relevance, functional design, and instructional utility. By doing so, the study contributes to the growing body of literature on evidence-based instructional media development and offers practical implications for educators and instructional designers working in technical education contexts.

METHOD

This study adopts a Research and Development (R&D) methodology aimed at producing a valid instructional medium in the form of a Logic Gate Trainer Kit to support teaching and learning in the field of digital electronics. The R&D approach was selected due to its suitability for systematically designing, developing, and evaluating educational products that are intended to solve specific instructional problems. This study implements the Instructional Development Institute (IDI) model, which provides a structured and iterative framework for instructional media development.

Figure 1. Instructional Development Institute (IDI) Model

The IDI model comprises three major phases: Define, Develop, and Evaluate. Each phase is designed to ensure that the product is not only pedagogically sound but also technically functional and aligned with learner needs.

- In the Define phase, a comprehensive analysis was conducted to identify instructional goals, learner characteristics, content structure, and performance requirements. This phase serves as the foundation for all subsequent development activities.

- The Develop phase involved the actual design and construction of the Logic Gate Trainer Kit. Instructional specifications, technical components, and user interface considerations were translated into a functional prototype. This stage emphasized usability, alignment with curriculum content, and support for hands-on experimentation in learning logic gates.
- The Evaluate phase focused on determining the validity of the developed media through structured expert reviews. Both media experts and subject matter experts were engaged to assess the quality of the trainer kit in terms of content relevance, visual and physical design, functional accuracy, and instructional alignment.

This design model ensures that the instructional media is grounded in both theoretical rigor and practical relevance, providing a product that is systematically planned, evidence-based, and suitable for implementation in real-world educational settings. The emphasis on expert-based validation in the final stage distinguishes this research as a validity-focused study, contributing to the broader discourse on quality assurance in instructional media development.

Research Setting and Participants

The research was conducted at the Academy of Community-Based Mining Industry (Akademi Komunitas Industri Pertambangan Bukit Asam), specifically within the Department of Mining Equipment Maintenance (Program Studi Perawatan Alat Tambang). This institution offers vocational and technical education focused on the mining industry and related mechanical and electrical systems, making it a relevant setting for the development and implementation of digital electronics instructional tools such as the Logic Gate Trainer Kit.

The participants in this study were selected through purposive sampling, a non-probability sampling technique that allows researchers to deliberately select individuals who possess specific expertise relevant to the objectives of the study. This technique was chosen to ensure that the evaluation of the trainer kit was conducted by individuals with recognized qualifications and practical experience in the domains of instructional media design and electronics engineering education.

A total of eight expert validators were involved in the study, divided into two distinct groups:

1. Four media experts, who possess academic and professional backgrounds in instructional design, educational technology, and technical media development. These experts were responsible for evaluating the trainer kit based on criteria such as visual layout, usability, functionality, clarity of instructions, and the pedagogical alignment of the media with learning objectives.
2. Four subject matter experts, consisting of lecturers and practitioners with extensive knowledge and experience in digital electronics, particularly in the teaching of logic circuits and gate operations. These validators assessed the trainer kit in terms of technical accuracy, content relevance, and its alignment with curricular standards in vocational electronics education.

All validators were recruited based on their professional qualifications, institutional affiliations, and publication or project experience in their respective fields. Their role in this study was to provide both quantitative ratings and qualitative feedback regarding the effectiveness, relevance, and technical appropriateness of the developed instructional media.

The selection of participants from both media and subject matter domains ensures a balanced and comprehensive validation process. This dual-perspective validation approach enhances the reliability and validity of the study's findings, particularly in the context of educational media development where both pedagogical quality and technical accuracy are critical.

Data Analysis Techniques

To assess the validity of the developed Logic Gate Trainer Kit, the study employed quantitative content validation techniques based on expert judgment. The primary analytical tool used was Aiken’s V coefficient, a statistical method specifically designed to measure the level of agreement among expert raters regarding the relevance and clarity of items or components in an instructional product. Aiken’s V is widely recognized in educational research as a reliable indicator for evaluating the content validity of newly developed instruments and media.

Each item in the expert validation sheet was rated using a four-point Likert scale, ranging from 1 (not relevant) to 4 (very relevant). This scale allows for nuanced assessment while avoiding a neutral midpoint, encouraging experts to make a definitive evaluation of each aspect under review. The aspects evaluated by media experts included layout design, usability, interface clarity, instructional alignment, and functional integration of components. Meanwhile, the subject matter experts focused on the technical accuracy of the logic gate circuits, content consistency with curricular standards, and the instructional value of the trainer kit. The Aiken's V coefficient was calculated using the following formula:

$$V = \frac{\sum s}{n(c-1)}$$

Each calculated V value ranges from 0 to 1, with higher values indicating stronger agreement among experts regarding item relevance. According to Aiken's validity threshold table, with n = 4 raters, each calculated V value ranges from 0 to 1, with higher values indicating stronger agreement among experts regarding item relevance. By employing a rigorous and statistically supported method of data analysis, this study ensures that the conclusions regarding media validity are not only empirically grounded but also generalizable within the scope of instructional media development in vocational and engineering education.

RESULT AND DISCUSSION

Product Design

The instructional media developed in this study is a Logic Gate Trainer Kit, specifically designed to facilitate student learning in digital electronics courses by providing an interactive and tangible representation of logic gate operations. The product was created to address the limitations of conventional instructional methods, which often rely heavily on abstract theory and computer-based simulations and may not sufficiently support students' conceptual understanding and practical skills especially in vocational education settings. The schematic diagram of the circuit used in the trainer kit is illustrated in Figure 1.

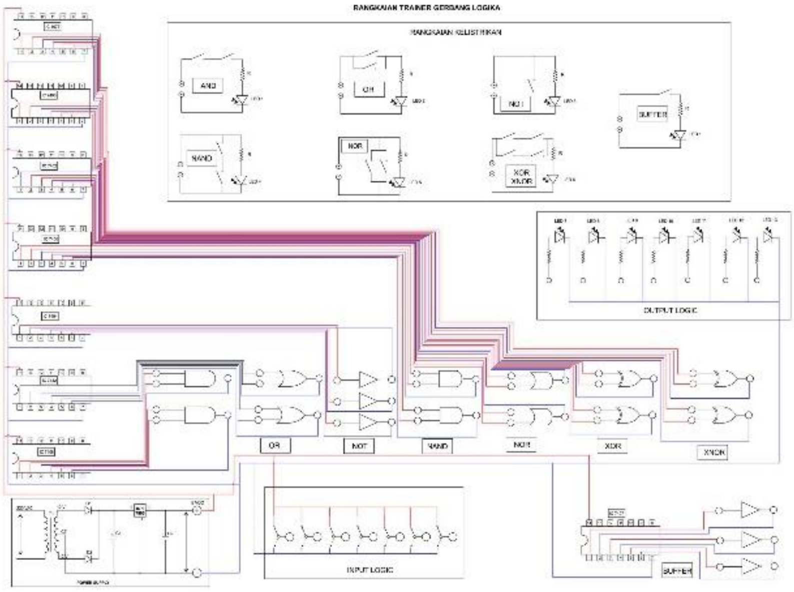

Figure 1. Schematic Circuit Design of the Logic Gate Trainer Kit

The trainer kit was designed through a user-centered development process, emphasizing ease of use, instructional alignment, modularity, and visual clarity. It enables students to physically construct and observe the behavior of basic logic gates, such as AND, OR, NOT, NAND, and NOR, through real-time input and output manipulation. This practical experience is particularly valuable for learners in applied science and engineering programs, such as those offered in the Mining Equipment Maintenance Program at the Academy of Community-Based Mining Industry (Akademi Komunitas Industri Pertambangan Bukit Asam).

The trainer kit incorporates a range of electronic and mechanical components, chosen for their relevance to instructional goals and durability in classroom environments. The components used include:

1. Logic Gate ICs: 7408 (AND), 7432 (OR), 7404 (NOT), 7400 (NAND), and 7402 (NOR), which serve as the core functional units for logic operations.
2. Breadboard: Utilized as a prototyping platform to facilitate flexible circuit assembly without soldering, allowing students to modify configurations easily.
3. Input Devices: Push buttons are used to simulate binary logic inputs (0 and 1) to test gate functionality in real time.

4. Output Indicators: Light-emitting diodes (LEDs) are implemented to visually display the logic gate outputs based on the input conditions, providing immediate feedback to learners.
5. Resistors: 220-ohm and 1k-ohm resistors are used to limit current, ensuring component safety and circuit reliability.
6. Power Supply: A stable 5V DC power source is integrated to meet the standard voltage requirements for TTL logic ICs.
7. Switches and Connectors: Installed to allow user control and to facilitate easy circuit configuration and transitions between experiments.
8. Protective Case and Instructional Overlay: The trainer kit is housed in an acrylic case with labeled overlays, which not only protect the internal components but also guide users in the operation and circuit identification process.

The physical layout of the trainer kit was designed for compactness, clarity, and instructional efficiency, enabling students to engage with the material individually or in small groups. The clear labeling and modular component placement assist in reducing cognitive load and minimizing errors during assembly. The assembled trainer kit is shown in Figure 2.

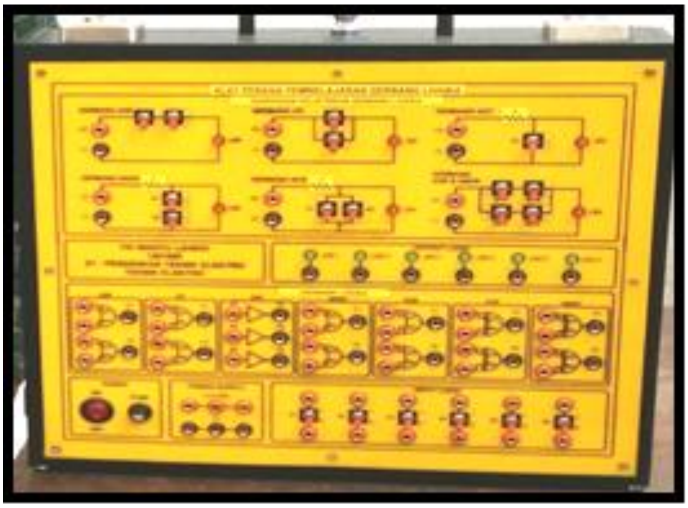

Figure 2. Final Physical Design of the Logic Gate Trainer Kit

Validity Analysis Results

To ensure the instructional quality, technical feasibility, and pedagogical relevance of the developed Logic Gate Trainer Kit, a comprehensive validation process was carried out. This process involved a structured evaluation by a panel of experts comprising two groups: media experts and subject matter experts, each consisting of four individuals with professional expertise in their respective domains. The purpose of this validation was to determine the extent to which the trainer kit meets the essential criteria for effective instructional media in technical and vocational education contexts.

Each expert was provided with a validation instrument consisting of several indicators organized into evaluation domains, including content relevance, technical accuracy, instructional design, usability, and visual presentation. The experts were asked to rate each indicator using a four-point Likert scale, with values ranging from 1 (not relevant) to 4 (very relevant). The instrument was developed based on standard instructional media evaluation frameworks and adapted to the specific characteristics of the trainer kit. The analysis results for both groups of validators are summarized in Table 1.

Table 1. Aiken's V Validity Coefficients

Validator Group	Number of Experts	Average Aiken's V Score	Validity Threshold (≥ 0.667)	Validity Status
Media Experts	4	0.78	Met	Valid
Subject Matter Experts	4	0.82	Met	Valid

The results indicate that both sets of validators expressed a high level of agreement regarding the quality and appropriateness of the trainer kit. The media experts provided an average Aiken's V score of 0.78, demonstrating that the visual design, interface layout, instructional alignment, and usability aspects of the product were well-received and considered valid. Meanwhile, the subject matter experts reported an average V score of 0.82, indicating strong agreement on the accuracy of content, relevance of instructional objectives, and the appropriateness of the trainer kit for teaching digital logic concepts.

In addition to the quantitative ratings, qualitative feedback from experts offered suggestions for minor refinements, such as improving the contrast of LED indicators, enhancing label visibility, and including a modular guide sheet for student exercises. However, none of the feedback indicated the presence of fundamental flaws or misalignments with the intended instructional goals.

Overall, the validation process confirms that the Logic Gate Trainer Kit meets established standards for instructional media and is suitable for implementation in educational environments that require a balance of theoretical understanding and practical skill development. The positive validation results also provide empirical support for the continued development and potential dissemination of the trainer kit as a pedagogically sound and technically accurate learning tool.

CONCLUSION

This study has successfully developed a Logic Gate Trainer Kit as an instructional medium to support the teaching and learning of digital electronics, particularly in vocational and technical education contexts. Guided by the Instructional Development Institute (IDI) model, the development process systematically addressed the instructional needs through three phases: define, develop, and evaluate. The final product was designed to be practical, accessible, and pedagogically aligned with the curriculum of the Mining Equipment Maintenance Program at the Academy of Community-Based Mining Industry (Akademi Komunitas Industri Pertambangan Bukit Asam). The validity of the trainer kit was confirmed through expert evaluations using Aiken's V coefficient. Validation results from both media experts and subject matter experts indicated strong agreement regarding the instructional quality, content accuracy, and usability of the product, with average Aiken's V scores of 0.78 and 0.82, respectively. These findings exceed the minimum threshold for content validity, thus confirming that the trainer kit is a valid and reliable instructional tool. The Logic Gate Trainer Kit offers significant pedagogical value by providing a hands-on, interactive learning experience that helps bridge the gap between theoretical knowledge and practical application (Yanie, A. 2024), (Mustakim, W., et al. 2024). Its modular design and use of real components make it especially suitable for technical training environments, where experiential learning is essential (Kohpeisansukwattana, N., et al. 2024), (Petersen, F., et al. 2024), (Lee, E. 2025). Future studies are recommended to evaluate the effectiveness of the trainer kit in improving student learning outcomes through classroom trials or experimental research designs. Additionally, expanding the trainer kit to cover more advanced digital logic topics, such as flip-flops, multiplexers, or sequential circuits, may further enhance its educational utility. In conclusion, the Logic Gate Trainer Kit developed in this study represents a valid, functional, and pedagogically meaningful contribution to the field of instructional media for technical education and holds promise for broader implementation in STEM related learning environments.

REFERENCES

Fuada, S. (2022). Development of Educational Kit for Practical Course in the Topic of Phase-Shift RC Oscillator. *International Journal of Online & Biomedical Engineering*, *18*(5). https://doi.org/10.3991/10.3991/ijoe.v18i05.29131

Gao, K., Sun, B., Cao, Z., Duan, X., Yan, W., Tong, G., ... & Shao, J. (2024). Biomaterial/organic heterojunction based memristor for logic gate circuit design, data encryption, and image reconstruction. *Advanced Functional Materials*, *34*(36), 2401132. https://doi.org/10.1002/adfm.202401132

Ilyas, Q., Waseem, M. T., Junaid, H. M., Khan, Z. A., Munir, F., Shaikh, A. J., & Shahzad, S. A. (2022). Fluorescein based fluorescent and colorimetric sensors for sensitive detection of TNP explosive in aqueous medium: Application of logic gate. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, *272*, 120994. https://doi.org/10.1016/j.saa.2022.120994

Kholis, N., Zuhrie, M. S., & Burhanuddin, D. H. (2025). Development of Digital Electronics and Information Literacy Training Kit to Improve the Performance of Students Electrical Engineering Education. *IJORER: International Journal of Recent Educational Research*, *6*(2), 347-361. https://doi.org/10.46245/ijorer.v6i2.784

Kohpeisansukwattana, N., Siriwattananon, N., & Charoenwanit, E. (2024). Developing a Mobile Game Application to Enhance Learning Experience in Programmable Logic Controller (PLC) Wiring beyond the Laboratory. *International Journal of Interactive Mobile Technologies*, *18*(4). https://doi.org/10.3991/ijim.v18i04.42629

Lee, E. (2025). Development and implementation of an arduino-based digital logic circuit practice board module. *Education and Information Technologies*, 1-34. https://doi.org/10.1007/s10639-025-13604-7

Li, L., Yao, J. Y., Xu, J. X., Zeng, X., Wang, X., Shi, J., ... & Li, K. (2025). Bioinspired Molecular Logic Gate for Sequential Monitoring of ROS and Tyrosine Hydroxylase Activity in Hypertension. *Sensors and Actuators B: Chemical*, 138361. https://doi.org/10.1016/j.snb.2025.138361

Li, Y., Xiao, T. P., Bennett, C. H., Isele, E., Melianas, A., Tao, H., ... & Talin, A. A. (2021). In situ parallel training of analog neural network using electrochemical random-access memory. *Frontiers in Neuroscience*, *15*, 636127. https://doi.org/10.3389/fnins.2021.636127

Mustakim, W., Effendi, H., Giatman, M., & Wulandari, D. P. (2024). Development of Internet of Things Trainer Kit as a Learning Media for Digital Circuit Subjects in Higher Education. *International Journal of Online & Biomedical Engineering*, *20*(9). https://doi.org/10.3991/ijoe.v20i09.48349

Owolabi, A. O., Oke, A. O., Obalalu, A. M., Khan, U., Prasad, B., & Bajaj, M. (2024). Development of an Energy-Efficient Digital Trainer for Logic Design Education Using ATmega328P Microcontroller. In *E3S Web of Conferences* (Vol. 591, p. 08001). EDP Sciences.

Petersen, F., Kuehne, H., Borgelt, C., Welzel, J., & Ermon, S. (2024). Convolutional differentiable logic gate networks. *Advances in Neural Information Processing Systems*, *37*, 121185-121203. https://doi.org/10.1051/e3sconf/202459108001

Qi, S., Li, X., Zhao, C., Tang, Y., Chen, W., Zou, H., & Huang, S. (2025). Application of explainable machine learning to eXtreme Gradient Boosting models of all-optical logic gates. *Optical Engineering*, *64*(4), 048103-048103. https://doi.org/10.1117/1.oe.64.4.048103

Widinata, F., & Wirawan, I. M. (2025). Development of Programmable Logic Controller (PLC) Trainer Learning Media for Industrial Automation. *Edunesia: Jurnal Ilmiah Pendidikan*, *6*(2), 766-783. https://doi.org/10.51276/edu.v6i2.1229

Yanie, A. (2024). The Effect of the Application of Logic Gate Learning Media It-Based to Improve Motivation and Learning Outcomes Students. *JMRI Journal of Multidisciplinary Research and Innovation*, *2*(1), 15-23. https://doi.org/10.61240/jmri.v2i1.60