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The Validity and Reliability of the PLC Module in PLC Programming and Applications Topics

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Abstract

The advancement of technical and vocational education requires the integration of effective teaching aids that support both theoretical understanding and practical skills. The purpose of this study is to evaluate the validity and reliability of the PLC Module in PLC programming and applications topics. A total of seven experts in Programmable Logic Controller (PLC) from various institutions and industry reviewed the module's content validity. A pilot study was conducted with 30 polytechnic students who engaged in all activities outlined in the PLC Module to evaluate its reliability. This phase was followed by an assessment of the students' feedback using a module reliability questionnaire. The findings show that the developed module has high validity with a content validity coefficient of 0.92 and excellent reliability with a Cronbach's alpha value of 0.98. These results indicate that the PLC Module PLC programming and application topics are suitable for use. Additionally, feedback from both experts and students will be used to further refine the content, ensuring the developed module can meet the objectives and can be implemented. Furthermore, these findings have significant implications for the teaching and learning of PLC, specifically PLC programming and applications topics, whereas the PLC Module can serve as a valuable resource for educators and students in this field.

1. Introduction

Technical and Vocational Education and Training (TVET) in Public Higher Education Institutions (IPTAs) focuses on knowledge and skills to meet industry requirements, thereby producing human capital that aligns with industry needs [1]. The rapid evolution of industries' activity and skill demand necessitates significant modification in vocational education programmes to stay aligned with these changes [2]. Programmable Logic Controllers (PLCs) are essential in various industries, resulting in a growing need for skilled workers, hence, making PLC programming a very important ability for future electrical engineers in automation [3], [4].

The Programmable Logic Controller (PLC) & Automation course. This course is a compulsory subject for Diploma of Electrical Engineering in Polytechnic Malaysia. Students are taught PLC programming concepts and applications where students are required to construct PLC programming using ladder diagrams. However,

currently there is no dedicated module that covers both theory and practical work for PLC and Automation courses in polytechnics in Malaysia.

Thus, the PLC Module was introduced as a teaching aid to help students understand the PLC programming and applications. It is developed using the ADDIE model, applying behaviourism and cognitivism learning theories. This module will also help students as guided self-study material due to the videos on PLC programming simulation that are included in the module. This study aims to evaluate the validity and reliability of the PLC Module in PLC programming and applications topics.

Nomenclature	
ADDIE	Analysis, Design, Development, Implementation, and Evaluation
PLCs	Programmable Logic Controllers
IPTAs	Public Higher Education Institutions
TVET	Technical and Vocational Education and Training
x	Total Expert Scor
y	Maximum score

1.1 Literature Review

According to Klein [5], learning is an experiential process resulting in a relatively permanent change in behaviour that temporary states, maturation, or innate response tendencies cannot explain. Krishnamoorthy et al. [6] stated that learning theories provide frameworks for understanding the process of knowledge acquisition and learning. Throughout history, numerous learning theories have been developed, and they can be categorised into three primary perspectives: behaviourism, cognitivism, and constructivism [7].

Behaviourism, pioneered by Pavlov and Skinner, provides a theoretical foundation that views learning as observable behavioural change shaped by external stimuli and reinforcement [8]. Pavlov's work emphasises conditioned reflexes and habit formation, while Skinner highlights explicit behavioural modifications resulting from reinforcement [9]. Similarly, behaviourists Watson and Thorndike describe learning as a modification of behaviour triggered by external stimuli and reinforced through positive or negative feedback [10]. From an instructional perspective, behaviourism regards the educator as the facilitator of knowledge, highlighting systematic delivery, practice, and reinforcement to guarantee students achieve the desired outcomes [11]. This perspective aligns with the use of traditional teaching strategies such as lectures, drills, and standardised assessments that facilitate the acquisition of specific facts and skills. In the context of TVET, behaviourist approaches are particularly relevant, as competency-based training depends on reinforcement, repetition, and structured instruction to ensure the mastery of technical skills and consistent performance in industry-related tasks.

Cognitivism, on the other hand, which has its roots in Gestalt psychology and was created by Wolfgang Kohler in the early 1900s, redefines learning as the active building of knowledge by focussing on the mental processes of learners, such as attention, memory, and problem-solving [12], [13]. Cognitivist viewpoints place a strong focus on learners' active participation in their learning and application of knowledge, internal mental structures, and logical reasoning [14]. This theory also emphasises how crucial it is for educators and instructional designers to analyse learning activities and design strategies that support efficient information processing and cognitive development [15]. Cognitivism offers TVET contexts important insights into how to design instruction that improves students' problem-solving, reasoning, and adaptability skills, all of which are critical in fast-paced industrial settings while simultaneously fostering technical competency.

Instructional materials are tools or resources used by educators to support and facilitate the teaching and learning process to help students achieve the learning objectives [16]. Through concrete examples, visual representations, and interactive experiences, these instructional materials aim to support and enhance the teaching and learning process, promoting teachers' effectiveness and improving students' performance [17]. A module is a systematically designed learning tool that combines procedures, methods, and content to assist students in learning specific skills [18]. As structured and organised tools, teaching modules are essential in supporting learning objectives, enhancing instructional effectiveness, and improving educational quality [19]. To be effective, modules must incorporate key concepts, interesting content, contextual information, and sequential activities that are suited to the needs of the learners. They must also be in line with curricular standards, assessment criteria, and learning principles [18], [19].

The ADDIE model is a commonly used instructional design framework in education. Dick and Carey [20] state that ADDIE stands for Analysis, Design, Development, Implementation, and Evaluation. In the analysis phase, the instructional designers identify learner or student requirements, define learning objectives, and analyse the learning environment [21]. The design phase requires the design of a detailed instructional blueprint outlining content organisation, instructional strategies, and assessment methods [22]. The development phase then

Emerging Advances in Integrated Technology Vol. 7 No. 1 (2026) p. 15-22

produces the actual instructional materials such as user guides, instructional content, training, and stimulating materials based on the design blueprint [21], [22].

In the implementation phase, experts and target students test the developed module to determine its validity, reliability, identify its strengths and weaknesses, and improve the contents before implementing them in the classroom [21], [22]. Evaluation, which occurs throughout the ADDIE process, uses both formative and summative assessments to determine the effectiveness of instructional materials, measure student achievement, and improve learning experiences [23], [24]. This ongoing evaluation ensures that instructional modules remain effective, relevant, and aligned with desired learning outcomes.

Validity and reliability are essential quality assurance components in module development, wherein, in this stage, the module is evaluated and improved to produce proficient graduates that meet industry standards. Tarmizi and Janan [25] define validity as the degree to which a module accurately assesses its intended construct, ensuring alignment with learning objectives, curriculum standards, and the student's needs. Content validity is typically conducted through expert evaluation, where subject experts review the module to assess whether the instructional materials, activities, and assessments are comprehensive, relevant, and representative of the intended learning outcomes [25], [26], [27]. The analysis involves calculating percentage value using a specific formula. A module has high content validity when it receives a score of more than 70% [28].

Module reliability refers to the consistency of the module's instructional quality and effectiveness [28], where the students can achieve the learning objectives and successfully follow the steps for each activity in the module [27]. Sidek and Jamaludin [28] suggest that to test the value of the reliability coefficient of a module, the method of creating a questionnaire or question items can be made based on the steps of the module's activities or the objectives of the module. The instrument's reliability is determined by calculating Cronbach's alpha coefficient for each survey item in the questionnaire. Hair [29] emphasized that an instrument can be considered reliable when respondents consistently provide similar responses. Cronbach's Alpha value between 0.8 and 0.9 is classified as very good, while values between 0.7 and 0.8 are considered good.

2. Research Methodology

The research design of this study is module development, where the ADDIE model was applied during the design, development and implementation process. This study used a quantitative approach because the instruments provided data in numbers, which were analysed using statistical tests [30]. Validity guarantees that the module's design accurately assesses the specific function it aims to improve, while reliability ensures that the module produces consistent results over time and under various circumstances [28], [31]. A questionnaire will be given to the content experts for content validity and to the students in the pilot group to test the module and instrument reliability. The study used a descriptive study design aimed at measuring the validity and reliability of the PLC module. Quantitative data was analysed using SPSS version 20, focusing on mean scores through descriptive analysis.

There are two groups of samples in this study. The first group consisted of seven content experts who evaluated the validity of the module. The second group consisted of 30 fourth-semester students enrolled in the Diploma in Electrical Engineering program at Politeknik Sultan Azlan Shah. These students are in the target population but not in the final sample. The findings and feedback of the respondents in this pilot study were considered for refining the PLC Module prior to the actual study on the intended target.

There are two methods of validity carried out, namely face validity and content validity by external experts. The face validity was conducted after the PLC module completion where the content was checked by two senior lecturers in the PLC course and the language was checked by one language expert. Amendments were made based on feedback from the experts. Next the module when through content validity assessment where seven experts from various institutions and industry commented on the module content. The experts chosen have more than ten years of working experience with the PLC, either in an educational or in an industrial context. To determine the validity of the module content, the expert's total score (x) will be divided by the maximum score (y) and multiplied by one hundred. The formula is as stated below:

$$\frac{Total\ Expert\ Score\ (x)}{Maximum\ score\ (y)} \times 100\% = Level\ of\ Module\ Validity\ Percentage \quad (1)$$

The module validity questionnaire is an adapted version of Sidek and Jamaludin's [28] questionnaire designed to assess the content validity of a module. They used Russell's [26] content validity criteria, which include five important points: (a) the module content is appropriate for the target population, (b) the teaching methods or module implementation strategies is appropriate, (c) the time given for module implementation is sufficient, (d) the module should effectively improve student achievement in the targeted area, and (e) the module should successfully change student attitudes. This questionnaire is in the form of a five-point Likert scale, namely Strongly Agree (5), Agree (4), Uncertain (3), Disagree (2), and Strongly Disagree (1).

The module reliability is determined by calculating Cronbach's alpha coefficient for each survey item in the questionnaire, answered by the students in the pilot test group. The alpha Cronbach coefficient was used as an analytical tool to measure the reliability of the module activity. This is a standard practice when utilising the SPSS application. A Cronbach's alpha value between 0.8 and 0.9 is classified as very good, while values between 0.7 and 0.8 are considered good [29].

3. Research Findings

There are two research findings in this research, the PLC Module validity and reliability.

3.1 Module Validity

Feedback from the seven content experts was analysed by using the module validity percentage. The seven content experts consisted of two syllabus developers of the PLC course for Polytechnic Malaysia, one senior lecturer that has more than ten years of experience teaching the PLC course, three content experts from various universities in Malaysia and one expert from industry that has more than ten years' experience using the PLC. Table 1 shows the results of the module content validity percentage based on the content validity criteria while Table 2 shows the results determine by each of the content experts.

Table 1 *Module content validity percentage (Content validity criteria)*

Main criterion	Percentage (%)	Expert's judgment
a. The module content is appropriate for the target population.	97	Accepted
b. The teaching module implementation strategies is appropriate.	91	Accepted
c. The time given for module implementation is sufficient.	92	Accepted
d. The module should effectively improve student achievement in the targeted area.	93	Accepted
e. The module should successfully change student attitudes.	90	Accepted

Table 2 *Module content validity percentage (Individual expert)*

Expert	Expert Profile	Percentage (%)	Expert's judgment
1	Polytechnic PLC course content developer	95	Accepted
2	Polytechnic PLC course content developer	91	Accepted
3	Polytechnic lecturer	92	Accepted
4	University lecturer	93	Accepted
5	University lecturer	79	Accepted
6	University lecturer	91	Accepted
7	Industrial Expert	100	Accepted
	Average	92	Accepted

Based on the results shown in Table 1 and Table 2, the content validity for the PLC Module is high, ranging from 90% to 97% for the five content validity criteria, whereas for the percentage determined by each of the content experts, it ranges from 79% to 100%. All seven experts agreed that the teaching module should be relevant for the targeted learners, use the right methods of implementation in sufficient time, and improve both student performance and attitudes in the intended area. The experts' average acceptance score is 92%, indicating a high degree of content validity. Although some improvements are needed, the learning module is deemed suitable for use. Improvements to the module content were made based on the written feedback and suggestions given by the experts. Table 3 shows the summary of feedback and suggestions given by the experts.

Emerging Advances in Integrated Technology Vol. 7 No. 1 (2026) p. 15-22

Table 3 *Experts' feedback and suggestions*

Expert	Feedback and Suggestions
Expert 1	- The module is well arranged and suitable to be used for the PLC course for Polytechnics students. - Add voice or text to the videos provided in the module.
Expert 2	- The module is suitable to be used as reference material for the students. - Declare the type of PLC model used for the ladder diagram in the module. - Add voice to the videos provided in the module. - Provide answers to the practice questions given.
Expert 3	- The module content can improve the students' understanding of PLC programming. - Add voice or text to the videos provided in the module. - Add explanation on how to determine the input output devices in Unit 6 and 9. - Include the list of RLL symbols for Unit 7 for student's reference.
Expert 4	- The module is suitable for use by diploma students. The module structure is suitable. - Add voice to the videos provided in the module. - Add visual on PLC application and HMI on the module cover.
Expert 5	- The module is suitable for use by diploma students. - Add theory on PLC hardware, input and output wiring as well other types of PLC programming such as sequential function chart in the module.
Expert 6	- The module is good. It is packed with important information and suitable diagrams for the course. - Add voice to the videos provided in the module. - Add theory on PLC wiring.
Expert 7	- The module content covers the basic PLC knowledge needed in industry. - The videos are compact and easy to understand. - Add extra explanation for the interlock and interlock clear instructions.

3.2 Module Reliability

A questionnaire on module reliability was distributed to 30 students during the pilot study to evaluate their understanding of the PLC module components. Based on the 49 items in the module reliability questionnaire, the overall Cronbach's alpha value obtained by the module is 0.980, indicating the module has high reliability. The Cronbach's alpha for each unit in the module is as shown in Table 4. The Cronbach's alpha for each unit ranging from 0.805 to 0.916. The results indicate that the PLC Module can achieve its objectives if students follow the module content and perform all activities provided in the module. Furthermore, the students also give feedback and suggestions on the module content. The majority of the students agreed that the module was easy to understand and follow. In addition, the videos provided in the module were helpful, but they would be better if voice was added. Some of the students also suggested providing answers to the practice questions given.

Table 4 *Module reliability*

Unit	Alpha Value
Introduction	0.822
Unit 1 Instruction PLC Programming Methods Ladder	
Unit 2 Ladder Diagram	
Unit 3 Basic Logic Instruction Set	0.849
Unit 4 Special Sequential Function	0.838
Unit 5 Timer and Counter Instruction	0.844
Unit 6 Apply PLC Instruction	0.899
Unit 7 Translation of Hardwired RLL to PLC Ladder Logic	0.805

Unit	Alpha Value
Unit 8 Human-Machine Interface (HMI)	0.892
Unit 9 PLC Applications	0.916

4. Discussion

The expert evaluation shows that the PLC Module has a high level of content validity, with an average acceptance score of 92%. This result indicates that the module content is correct, useful, and suitable for the target group. It surpasses the standard threshold of 70% required for content validity [25], [28]. The expert consists of a wide range of professionals, including syllabus developers, senior lecturers, university academics, and an industry practitioner. Based on the written comments from the experts, the module is reliable as a balanced instructional resource that is academically sound while still being in line with the industry needs.

The feedback from experts confirms that the module's design is iterative and adaptable. Suggestions like making the PLC model type clearer and giving answers to practice questions point out areas in the module that need improvement. These comments were in line with the students' feedback, especially when it came to the need for narration in the instructional videos provided in the module. The merging of expert and student views makes the module more relevant and shows how well the ADDIE methodology works to facilitate ongoing improvement through systematic evaluation.

The reliability analysis indicated Cronbach's alpha coefficient of 0.990, demonstrating a very high level of internal consistency among the 49 questionnaire items. This value exceeds the established benchmark of 0.9 for excellent reliability [29], confirming that the module reliably supports the intended learning outcomes. Reliability coefficients at the unit level ranged from 0.805 to 0.916, indicating that each section of the module offers coherent instructional support while maintaining overall consistency. The results indicate that the PLC Module can achieve its objectives if students follow the module content and perform all activities provided in the module.

From an educational perspective, this reliability guarantees students engage in structured progression across units, enabling them to systematically master PLC programming. In a TVET context, where the primary objective is to produce graduates with demonstrable competencies for industry application, this reliability is essential. This ensures that repeated exposure to the module produces consistent learning outcomes across various student cohorts, thus facilitating scalability and sustainability in its implementation at polytechnics [27], [28].

The findings affirm the pedagogical significance of integrating instructional materials with course-specific outcomes. However, there is currently no dedicated module that combines theory and practice for PLC and Automation course in Malaysian polytechnics. This study fills that gap by creating a subject-specific module focused on PLC programming and applications, which is a key component of the Programmable Logic Controller (PLC) & Automation syllabus. The alignment between instructional materials and learning objectives is essential for assuring skill transferability and increasing student confidence in applying knowledge in real-world industrial settings.

5. Conclusion

A teaching module is considered comprehensive and quality after its validity and reliability are confirmed [28]. There have been many research studies conducted on the development of teaching modules where the module validity and reliability are verified, such as Tarmizi and Janan [2022], Nawi et al. [27], Idris and Che' Rus [31] and, Bakar and Ismail [32]. Hence, it is crucial that a new developed teaching module undergo these steps to ensure the credibility of the module.

The PLC module demonstrated strong validity and reliability, affirming its potential as a high-quality instructional resource for PLC and automation courses in Malaysian polytechnics. The alignment of the module with course content has addressed the research gap identified in the literature, confirming the value of subject-specific teaching materials in technical education. By incorporating feedback from both experts and students to improve the module, the module serves as a dynamic learning instrument that is adaptable to future industrial and educational demands. This establishes the module as a substantial advance to TVET pedagogy, directly impacting graduate competency and industrial preparedness.

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Conflict of Interest

The authors declare that they have no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Nurul Azimah Ahmad Arzaai, Irdayanti Mat Nashir;* ***data collection:*** *Nurul Azimah Ahmad Arzaai;* ***analysis and interpretation of results:*** *Nurul Azimah Ahmad Arzaai, Saiful Adli Yusoff;* ***draft manuscript preparation:*** *Nurul Azimah Ahmad Arzaai, Saiful Adli Yusoff. All authors reviewed the results and approved the final version of the manuscript.*

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