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Validity and Reliability of a Rekatronik Module for Electronic Design in the Design and Technology (D&T) Subject

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ABSTRACT

The aim of this study was to evaluate the Rekatronik Module's reliability and validity. Nine experts in electronics education and teaching and learning reviewed the module's content validity. A pilot study involving 30 secondary school students who participated in all activities specified in the Rekatronik Module was conducted to assess its reliability, followed by an evaluation of the students' feedback through a module reliability questionnaire. The module had good content validity with a content validity coefficient of 0.87 and excellent reliability with a module reliability coefficient of 0.90, according to the experts' consensus. The present study has demonstrated that the Rekatronik Module the Rekatronik Module, which is grounded in project-based learning (PjBL) has a high level of reliability and validity, making it suitable for use. The pilot study, which evaluated the usability of the module among the target group, contributed to the high level of reliability achieved. Additionally, experts in the field of electronic design and technology subject validated the module's content, leading to a high level of content validity. These findings have significant implications for the teaching and learning of electronic design and technology, and the Rekatronik Module can serve as a valuable resource for educators and students in this field.

1. Introduction

Education plays a vital role in the development of a nation by enhancing the quality of human capital and improving the standard of living of the people [1]. In the context of Malaysia, various efforts have been made to advance the nation's education system. Education plays a key role in realising Malaysia's aspirations to be a developed nation [2]. The Malaysian government has taken several initiatives to ensure quality education is available to all its citizens, such as the Ministry of Education, the Malaysia Education Transformation Programme (ETP), and the Malaysia Education Blueprint 2015-2025 (MEB) [3]. The education system has been revamped to meet current needs, with more interactive and innovative teaching methods being introduced, including the implementation of technology-assisted teaching, and learning in classrooms.

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According to Yunus *et al.,* [4], innovation in education plays an important role in determining the direction of personal, social and economic growth within the nation.

Programmes such as STEM have also been introduced to promote innovation in education, demonstrating Malaysia's commitment to providing quality education and preparing its citizens for the challenges of the future. The education system's emphasis on science to produce more skilled STEM labor is important for the country's economy, and early exposure to scientific knowledge and its relation to STEM careers can positively impact student involvement if done transparently and structural [5]. STEM programs introduced in Malaysia include the subject of Design and Technology (D&T) aimed at providing practical skills in design and technology to students. The D&T topics cover the introduction to D&T, project management, design processes, ideas generation, and inventive problem-solving methods. The technological application comprises cross curricular topics related to science and technology, art, agriculture, food, and fashion [6].

Electronic design is one of the important topics in Design and Technology. Students learn basic electronic concepts and techniques for connecting electronic components with microcontrollers, simulation processes, and programming. Microcontrollers consist of microprocessors, memory, and input/output devices for automatic control or data processing. Programming involves writing code to control microcontrollers, using specialized languages for decision-making and managing input/output devices. A microcontroller is an integrated circuit that is housed within each component that it needs to perform the necessary operations and that can perform a particular task routinely without requiring another boom [7]. Fundamentally, all electronic devices or equipment use a microcontroller as a brain for the devices [8]. Such knowledge about microcontroller is crucial for students to design and produce electronic project.

The development of instructional aids for the D&T subject, particularly for the topic of electronic design, is an effort to enhance student learning and understanding of the concepts and applications of electronic design. The resulting learning module, called the Rekatronik module, was developed based on a needs assessment that was analysed and translated into the required module format through a Project-Based Learning (PjBL) approach. The module was also rigorously tested for validity and reliability to ensure its quality and alignment with the module's objectives. A module needs to be cleared to determine the suitability and usability. The main characteristics in determining the suitability and usability of a material or an instrument are by obtaining the validity and reliability [9]. This initiative aims to provide an effective and engaging learning experience for students in electronic design.

The Sustainable Development Goals (SDGs) form part of the United Nations (UN) “2030 Agenda for Sustainable Development”, which was unanimously adopted in 2015 by all UN Member States as a “plan of action for people, planet and prosperity” [10]. One of the most prominent goals of the SDG is to provide learners with high-quality education (SDG 4) [11]. Among the many initiatives aimed at achieving this goal is the Malaysia Education Blueprint 2015-2025 (MEB) [3]. MEB is a comprehensive plan developed by the Malaysian government with the goal of transforming the country's education system to achieve sustainable development goals, particularly SDG 4, which emphasizes quality education. The MEB designed to improve the quality of education in Malaysia by increasing access to quality education, promoting innovative learning methods, and enhancing the quality of teaching and learning. The blueprint also includes initiatives to strengthen the governance of the education system, ultimately providing a roadmap to enhance the quality of education in Malaysia and contribute to the achievement of SDG 4.

The MEB contributes to the achievement of SDG 4 through various initiatives such as increasing the use of technology in teaching and learning processes, including the introduction of STEM programs (Science, Technology, Engineering, Mathematics). The Malaysia Education Blueprint 2015-2025 (MEB) has outlined STEM as a crucial element of student learning, aiming to strengthen the delivery of STEM across the education system. One of the subjects involved in STEM is design and technology (D&T), which is closely related to the production of innovative projects. According to the management guidebook for DT curriculum published by the Malaysian Ministry of Education's, project-based learning (PjBL) is one of the essential learning strategies that should be applied for this subject.

One of the approaches in STEM education is the use of project-based learning (PjBL) which makes learning more meaningful. The integration of technology in STEM education through the use of PjBL has been applied at the school level in most developed countries [12]. PjBL is a student-centered classroom activity that integrates various disciplines and connects real-life experiences. Electronic design is one of the topics included in the D&T curriculum. PjBL for electronic design provides a clear understanding to students on how the theory and practical aspects of the subject can be applied in real life situations. Effective implementation of this approach will contribute to strengthening STEM education across the country's education system. The Rekatronik module will be based on PjBL, which will involve several projects related to real-life situations. The validity and reliability of the module will be tested before implementation. The Rekatronik module will utilize PjBL as its foundation, with content that involves multiple projects related to real-world applications. Prior to implementation, the validity and reliability of the module will be thoroughly tested and verified.

Design and Technology (D&T) is a subject that emphasizes technology and engineering in its curriculum. The need to incorporate teaching aids into the D&T subject is critical as it involves practical or hands-on components in every topic. One such topic that requires teaching aids for teaching and learning processes is electronic design. Electronic design is an important and interesting topic in the modern world, widely used in communication, transportation, medicine, and other fields. However, mastering this field is challenging for students, particularly in practical learning aspects. The practical implementation process of electronic design experiments is time-consuming, and some students may need to extend their lab usage time to complete their practical studies [13]. Mastery of practical work related to electronics requires a strong foundation in logical thinking and basic knowledge of science, technology, engineering, and mathematics. According to a study by Sahaat and Nasri [14], the time required to complete a project on electronic design topic is longer compared to other topics.

Microcontrollers are also a major support in the process of implementing practical work on electronic design topics. Therefore, the selection of microcontrollers with good functional levels is important in providing short-term or long-term benefits to students. The results of a study by Noor and Saibon [15] showed that the analysis of teacher skills in using microcontrollers in the D&T subject is still at a new or early stage, and the frequency of microcontroller usage among teachers is still low. According to Yusof [12], during the delivery of teaching and learning on microcontroller topics in the D&T subject for Form 2 and Form 3, there are conflicts in choosing the use of microcontroller development boards. Further studies related to the D&T subject area also need to be conducted for improvement in terms of teaching and learning. Therefore, it is appropriate to have a learning module for electronic technology topics that has an easily developed guide to assist in carrying out practical work. This allows teachers to better understand the topic and can shorten the time of practical implementation.

In general, this study aims to develop Rekatronik module for D&T Subject. Therefore, the objectives of this study are as follows:

i. Determine the content validity of the Rekatronik module for D&T Subject.
ii. Determine the reliability of the Rekatronik module for D&T Subject.

2. Methodology

2.1 Research Design

Validity and reliability are crucial aspects to consider when developing a Rekatronik module. In developing a Rekatronik module, it is essential to ensure that the research design is valid and reliable. Validity ensures that the module's design effectively measures the specific function it intends to improve. The accuracy of a module's concepts and contents, which are essential features of a good module, is referred to as module validity [16]. While reliability ensures that the module produces consistent results over time and across various conditions. Reliability aims to determine whether the measurements give the same answer when it is used to measure the same concept to a population or sample or the same respondents [17]. Although reliability is important for study, it is not sufficient unless combined with validity [18]. By incorporating these principles into the research design, developers can ensure that the Rekatronik module is effective and dependable in enhancing the targeted function or operation. This study involves assessment studies aimed at estimating the validity and reliability of the Rekatronik module developed for D&T Subject.

2.2 Respondents

This study involves the sampling of experts to evaluate the content validity of the module and sampling of students to access the reliability of the module. For this study, nine experts were chosen using purposive sampling based on their specialized knowledge in the relevant field, or their expressed willingness to participate. The purposive sampling technique was used to select the experts based on their knowledge in particular field or respondent wishing to be studied [19]. The experts were selected to assess the validity of the Rekatronik module for the D&T subject, and the utilization of purposive sampling ensures a targeted and representative selection of experts for this evaluation. In order to evaluate the reliability of the Rekatronik learning module, a pilot study was conducted on 30 students with similar characteristics to the actual study sample. The purpose of this pilot study was to assess the content of the module and identify any possible errors. A pilot study was regarded as an essential requirement in advance of the main study as a means of ensuring trustworthiness and utility [20]. Additionally, an assessment of the usage of the learning kit was carried out to determine areas for improvement, if necessary. The form 2 students have taken D&T subject; hence they are eligible to evaluate the reliability of the Rekatronik module designed for D&T subject. The demographic information of the respondents involved in this study is shown in Table 1.

Table 1
Demographic information of respondents in the study

Purpose	Respondence	Number of respondents	Sampling technique
Content validity	Expert	9	Purposive sampling
Reliability	Student	30	Purposive sampling

2.3 Instrument

This study employs two different questionnaires to assess different aspects of a module used for teaching or training purposes. In order to evaluate the module, a questionnaire adapted from Jamaluddin [21] was distributed to the respondent. The questionnaire is structured as a five-point Likert scale, with the following response options: Strongly Agree (5), Agree (4), Uncertain (3), Disagree (2), and Strongly Disagree (1). The first questionnaire is the module content validity questionnaire, which is given to experts in the field to evaluate the module's content. These experts are typically individuals who have extensive knowledge and experience in the subject matter covered by the module. The purpose of this questionnaire is to ensure that the content of the module is accurate, relevant, and comprehensive.

The second questionnaire is the module reliability questionnaire, which is given to the students who participate in the module. The collected data were analyzed using SPSS software to determine the reliability coefficient, also known as Cronbach's alpha (α). The purpose of this questionnaire is to evaluate the reliability of the module's activities. Students are asked to provide feedback on the activities included in the module, such as whether the activities are clear and understandable, whether they are effective in facilitating learning, and whether they are appropriately challenging.

In summary, the module content validity questionnaire is used to ensure the accuracy and relevance of the module's content, while the module reliability questionnaire is used to evaluate the quality and effectiveness of the module's activities. These questionnaires provide valuable feedback to improve the module and ensure that it is meeting the intended learning objectives.

2.4 Data analysis

After the questionnaire forms have been validated by experts, they are collected and analyzed. The analysis involves calculating a percentage value using a specific formula. If the percentage obtained is 70 or higher, it indicates that the module activity has good content validity [22,23]. Content validity refers to the extent to which the content of the module accurately represents the intended learning objectives. In this case, if the experts' validation results in a percentage of 70 or higher, it suggests that the content of the module is relevant and comprehensive, and accurately reflects the intended learning objectives. Typically, the percentage value is calculated by dividing the number of items that received positive ratings by the total number of items in the questionnaire, and then multiplying the result by 100 as a formula below as Eq. (1). This percentage value provides an indication of the level of agreement among the experts regarding the validity of the module content.

$$\frac{Total\ Expert\ Score\ (x)}{Maximum\ Score}\ x\ 100 = \text{Level of Module Percentage} \quad (1)$$

The alpha cronbach is one of the most widely used measures of reliability in the social and organizational sciences [24]. The alpha cronbach coefficient was utilized as an analytical tool to measure the reliability of the module activity, which is a common procedure when employing the SPSS program. The alpha cronbach values provide information on the suitability and interrelatedness of items in a set of questions, with values approaching one indicating high reliability, effectiveness, and suitability. The reliability value of a measure is considered high when it exceeds 0.8 [25-27].

3. Results and Discussion

In this section, the researcher will discuss the validity and reliability analysis results of the Rekatronik learning module. The study will provide information on the type of questionnaire used and the number of experts involved in assessing the content validity of the module. The study will also provide information on the approximate percentage of agreement among experts in assessing the content validity of the module. The author will then discuss the analysis results and interpret whether the developed Rekatronik learning module has high content validity.

For reliability, the study will provide information on the type of questionnaire used and the number of respondents involved in testing the reliability of the module. The study will state the Cronbach's alpha value achieved by the module and compare it to the threshold value considered adequate in the context of the study. The author will then discuss the analysis results and interpret whether the developed Rekatronik learning module has high reliability.

Additionally, this study can provide a discussion of the implications of the analysis results on the effectiveness of using the Rekatronik learning module in the context of teaching and learning technology design in schools. The study can also provide suggestions for improving the module if necessary to enhance its validity or reliability.

3.1 Validity

To ensure the content validity of the Rekatronik learning module and kit, specialists with expertise in electronics and education were consulted. These specialists included D&T specialist teachers, lecturers from Higher Education Institutions (HEI), and engineers from the electronics industry. The expert agreement score for the module's validity is high and deemed suitable for use with some improvements. The updating and improvement process of the learning module and kit aims to enhance the quality of activities to align with the formulated topics and objectives.

According to Table 2, the percentage of expert agreement on the content validity of the Rekatronik learning module and kit is high, ranging from 83% to 96%. The experts' average agreement score is 90%, indicating a high degree of content validity. Although some improvements are needed, the learning module and kit are deemed suitable for use. The updating and improvement process aim to align the activities with the formulated topics and objectives to enhance the quality of the learning experience.

Table 2
Percentage Analysis of Rekatronik Module Content Validity

Expert	Expert Profile	Percentage
1	Expert Teacher	97
2	Expert Teacher	83
3	Expert Teacher	92
4	University Lecturer	94
5	University Lecturer	83
6	Polytechnic Lecturer	97
7	Electronics Engineer	88
8	Electronics Engineer	83
9	Electronics Engineer	92
	Average	90

3.2 Reliability

The second objective of this study is to evaluate the reliability of the Rekatronik module for the D&T subject, as defined by Russell [28] as the learners' ability to complete all module activities. A module reliability questionnaire was distributed to students during the pilot study to assess their comprehension of the Rekatronik module materials. Internal consistency for each topic was measured using Cronbach's alpha, resulting in high reliability values ranging from 0.808 to 0.808, as presented in Table 3. The overall reliability index for the Rekatronik module for the D&T subject was .827, indicating high reliability. Cronbach's alpha was utilized to assess the reliability of the module, with a value of over 0.60 considered acceptable and over 0.90 denoting very high reliability [23,29]. Therefore, this research demonstrates the high reliability coefficient of the Rekatronik module for the D&T subject. The findings suggest that the Rekatronik Module can accomplish its objectives if students complete all activities according to the module's goals, making it a readily available module that can be evaluated for effectiveness in the subsequent phase.

Table 3
Value Reliability in Rekatronik Module

Unit	Item	Alpha Value
1	Definition of electronic design	0.820
2	Basic process of electronic design	0.827
3	Definition of microcontroller	0.808
4	Types of microcontrollers	0.822
5	Difference between input, output, process	0.811
6	Examples of input	0.821
7	Examples of output	0.810
8	Function of microcontroller circuit devices	0.821
9	Process of creating an electronic design project	0.818
10	Block diagram drawing	0.821
11	Schematic diagram drawing	0.811
12	Circuit simulation	0.823
13	Programming the circuit functionality	0.821
14	Circuit connections	0.821
15	Programming software	0.828
16	Programming upload process	0.813
17	Functional testing of the circuit	0.816
18	Circuit improvement	0.813
19	Justification of control programming	0.816
20	Control programming arrangement	0.832
21	Project idea generation	0.838
22	Project creation process	0.823
23	Assistance from kits and modules in project creation.	0.828

4. Conclusion

The development of the Rekatronik module which is grounded in project-based learning (PjBL) for the D&T subject has been successful, with a content validity coefficient of .90 indicating high content validity. Additionally, the reliability coefficient of the Rekatronik module (α = 0.827) showed an acceptable level of internal consistency for the scale. This module can serve as a valuable resource and guide for teachers and students involved in teaching and learning D&T, particularly for electronics design topics. The high content validity and acceptable reliability of the Rekatronik module suggests that it is a reliable and valid tool that can enhance the quality of teaching and learning in the field of D&T.

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