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Assessing AR-MicroC: A Study on the Reliability and Validity of an AR Learning Module for IoT

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ABSTRACT

This study was conducted to determine the validity of the module and the reliability of the module in improving the achievement and motivation of Community College students in the introduction to the Internet of Things course. This module has been built based on the m-ADDIE model with five development phases. The instrument used for the study is a questionnaire on module content validity and reliability. The module was validated by 9 expert assessors, including public university lecturers and expert lecturers. They have expertise in content, language, multimedia, and technical design. The result of the expert evaluation shows that the validity value of the AR-MicroC Augmented Reality Learning Module shows a high degree of agreement which is 100% for language validity, 94% for content validity, and 91% for the validity of the multimedia and technical design of the module. The developed module also meets the aspects outlined in the course syllabus with slight improvements based on the comments made by the expert panel. The reliability of the module was obtained from 29 semester 3 students who participated in the implementation of the pilot study. The Cronbach's Alpha score obtained for reliability was 0.952. Expert opinion on the validity of this module is good. Positive feedback was received from respondents related to the reliability of the module which got a high reliability value. This finding reflects that this module can be adopted among students to improve their achievement and motivation when using AR-MicroC Augmented Reality Learning Module.

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1. Introduction

Today's progress is greatly influenced by the new technological environment known as Industrial Revolution 4.0 (IR4.0). IR4.0 has now changed the way in the field of life to digital technology. IR 4.0 also affects the world of education. With that, the term Education 4.0 was born which is a response to the needs of IR4.0 where people and technology are aligned for the exploration of new opportunities. In line with the important shift outlined in the Malaysian Education Development Plan 2015-2025 (Higher Education) through the ninth shift which is to take advantage of online learning at a global level to improve the quality of teaching and learning in Malaysia. With that, the opportunity has been available to teachers and students to take advantage of the use of technology, especially by combining the use of mobile devices and appropriate applications in the teaching and learning process [1-3]. In addition, the presence of a group of students known as Y and Z generation in today's learning era is also one of the factors that need attention because the student group has a high background and technological literacy [4]. Therefore, the teaching and learning approach implemented now should be designed and adapted according to the development of technology and the educational needs of the 21st century.

21st-century education emphasizes the skills needed to face increasingly complex and dynamic global challenges. It is no longer limited to the teaching of academic knowledge alone but also involves the development of skills and values that are important for success in an increasingly connected and high-tech world. 21st-century education and Technical and Vocational Education and Training (TVET) complement each other in preparing students for an increasingly complex and high-tech world of work. To support the aspirations and wishes of the government in empowering 21st Century Education and TVET, Kolej Komuniti also bears the responsibility as one of the stakeholders of TVET in Malaysia.

According to the Polytechnic and Community College Strategic Plan 2018-2025, TVET curricula needs to incorporate IR4.0 elements and embrace 21st-century pedagogy to produce globally competitive graduates (JPPKK, 2020). The Information Technology Certificate is one of the certificates offered at Community Colleges to produce individuals who have the potential to adapt to the use of technology and be responsible in computer systems and network technology to face new challenges in the field of information technology in line with the country's needs [5]. In response, Kolej Komuniti offers an Information Technology Certificate that prepares students to navigate technological demands in computer systems and network technology, an initiative supported by JPPKK's '4IR Flagship' program [5].

As part of the Information Technology Certificate program, students are required to take an Introduction to Internet of Things (IoT) course in their third semester. This course aims to build foundational knowledge of IoT concepts and applications, including microcontrollers. However, understanding microcontrollers, which involve programming and circuit assembly, is challenging for many students due to the need for visualization skills and creative thinking [6-8]. The lack of specialized resources to simplify these complex concepts further complicates the learning process for students and poses a challenge for lecturers. To address these challenges, integrating effective teaching aids becomes essential. Visual aids, such as learning tools, can significantly aid in explaining electronic concepts, enabling students to design and simulate electronic circuits on microcontrollers more effectively [9]. Recognizing this need, Augmented Reality (AR) technology offers a promising solution by incorporating interactive multimedia that enhances students' understanding of complex topics [10].

Techniques and methods of teaching and learning are now changing to the development of technology. Among the applications of concepts in the use of technology used in the renewal of this learning method is the use of Augmented Reality technology that emphasizes multimedia elements. Learning with the concept of cybergogy is one of the new dimensions in educational pedagogy where lecturers require different strategies in the teaching system, namely learning in the form of interactive multimedia [11] and the latest technology [12-14]. Furthermore, students now prefer lecturers to use the latest technology in teaching because it can improve academic achievement [15]. The implications will improve learning outcomes and have a positive impact on student attitudes where learning based on Augmented Reality becomes very interesting and fun.

Realizing the importance of technology in education, the use of mobile devices as a teaching medium is a catalyst to connect teachers, students, peers, and materials virtually on websites or learning applications for the learning process [5]. This can be seen through the activity of sharing learning materials between students who use smartphones because these devices have various applications that can be used for various activities. Students no longer need to face a personal computer to download notes or answer quiz questions or assignments. Additionally, students can access learning materials online. Mobile devices have also become a choice for lecturers for delivery in education because they can attract interest and improve student understanding [16]. The implications of the progress in mobile technology and the existence of a strong mobile platform, then the revolution of Augmented Reality through mobile devices [17]. The use of Augmented Reality technology in the classroom shows a widespread increase in student motivation and has a positive effect on learning outcomes where Augmented Reality-based learning becomes very interesting and fun [18]. This makes Augmented Reality a promising medium to train and stimulate students in various technical skills. In line with Belani and Aman [18] who found that learning using this technology can enhance student engagement and motivation.

However, despite the growing body of research highlighting the potential of AR in education, there remains a lack of empirical studies that specifically examine its implementation within technical and vocational education and training (TVET) contexts. Limited research has been conducted on how AR via mobile platforms can be systematically integrated to improve technical skills, engagement, and learning outcomes among TVET students. Therefore, this study aims to address this research gap by exploring the use of mobile-based AR applications in TVET settings to enhance the teaching and learning experience.

1.2 Research Objectives

The main purpose of the study is to examine the effects of the AR-MicroC Augmented Reality learning module that will be applied in learning the Introduction to the Internet of Things course at the Community College. Therefore, the specific objectives of the study are as follows:

i. Identify the validity based on the expert's view of the AR-MicroC Augmented Reality Learning Module that has been built based on the m-ADDIE Model.
ii. To identify the reliability of the module in relation to the content of the module and the objectives of the module in meeting the set targets.

1.3 Conceptual Framework

The conceptual framework shows the relationship between each study variable as well as the relationship of the variable with the chosen theory, model, or phenomenon. The independent variable involved in this study is the AR-MicroC Augmented Reality Learning Module used on

respondents. This AR-MicroC Augmented Reality learning module is developed based on Behaviorism Theory, Mayer's Cognitive Theory of Multimedia Learning, and the SAMR Model (Substitution, Augmentation, Modification, Redefinition). This learning module is also developed based on the m-ADDIE design model. The dependent variable for this study refers to the assessment of student achievement after using the developed module. The conceptual framework of this study is shown in Figure 1 below:

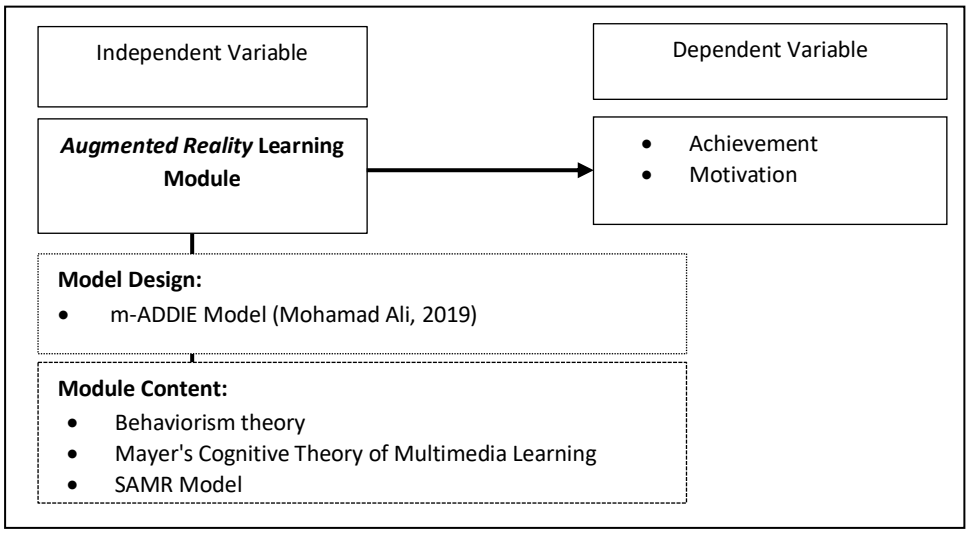

Fig. 1. Conceptual framework

2. Literature Review

The Internet of Things, better known as IoT is a concept developed to further expand the use and benefits of continuous internet connectivity. IoT is a technology that is aligned with facing the Industrial Revolution 4.0 (IR 4.0). According to Suman [20], IoT refers to connected devices that allow connection with other devices, then data is taken and processed into useful and relevant information. IoT also refers to connected devices that allow connection with other devices, after which data is retrieved and processed into useful and relevant information [21,22]. The rapid growth and application of IoT technology have created new opportunities for technological advancement in various fields. Therefore, it leads to great job opportunities for today's graduates. The Information Technology Certificate Curriculum developed is based on the Polytechnic and Community College Strategic Plan 2018-2025, where the offer of study programs is based on Industrial Revolution 4.0 (IR4.0) in producing quality and skilled Technical and Vocational graduates.

The focus of IR4.0 is also on the combination of cyber and physical systems. It touches on technology that also involves the use of Augmented Reality. The effort to develop Augmented Reality is believed to have started in the 1960s through the 3D graphic work done by Ivan Sutherland. However, only in the 1990s was there an effort to study it. In study by Azuma [23], the results of the study explain the field of Augmented Reality and describe the problems and a summary of its development. Since then, the development of Augmented Reality has been growing and has been applied in various fields such as the automated industry, medicine, education, and office environments.

According to Belani and Aman [18], the use of Augmented Reality technology in the classroom shows a widespread increase in student motivation and learning outcomes and has a positive effect on students' learning attitudes where Augmented Reality-based learning becomes very interesting,

fun, and interesting. This makes Augmented Reality technology a promising medium to train and stimulate students in various technical skills. Supported by Halim *et al.,* [24] who stated that learning using this technology is very helpful in a more effective learning and teaching process and can contribute to a more flexible environment. The benefits of technology integration can also improve the learning experience, better understanding of complex concepts, and increased student motivation [25-28]. Relatively, Augmented Reality technology is an interesting new field of study to explore. Most of the research efforts have developed until today encouraging the production of more applications based on Augmented Reality technology in society and digital communities. The issues and knowledge gained through the highlights of the study led to an initial study on the integration of mobile applications and Augmented Reality aimed at enriching the learning module in an immersive and more meaningful way.

Learning modules based on Augmented Reality can allow students to master skills and improve practical knowledge in certain fields. The use of modules not only allows users to understand the content of the lesson but can also increase their mastery of a topic contained in the module [29]. Various research findings show that module-based teaching has succeeded in improving student achievement in the field studied. This finding is also in line with studies by Jamen *et al.,* [30] that the application of Augmented Reality technology in teaching and learning has successfully improved student achievement and has a positive effect on students' visualization skills.

Learning modules based on Augmented Reality also have an impact on the motivation of its users. According to Goh *et al.,* [31], motivation is one of the factors that influence student success. A person will get the desired results in learning if there is a desire to learn. Motivation can be a driving force to achieve good results. Previous studies have shown positive changes in motivation domain for students who learn using the latest digital software such as mobile applications and Augmented Reality. This encouraging discovery was reviewed from various fields of education including in the fields of science and language. Research on Augmented Reality has also proven its very high usefulness in increasing student motivation in the learning process [32,33].

3. Methodology

3.1 Module Development

The development process for this learning module is based on the five phases of the m-ADDIE Model. The m-ADDIE model is an instructional design model that has been improved and modified from the original ADDIE model. This model can be used effectively as a guideline for the development of new educational software based on multimedia [34]. m-ADDIE is an acronym in 5 phases namely Analyze, Design, Development, Implementation and Evaluation and 'm' is dedicated to the development of multimedia educational software as in Figure 2.

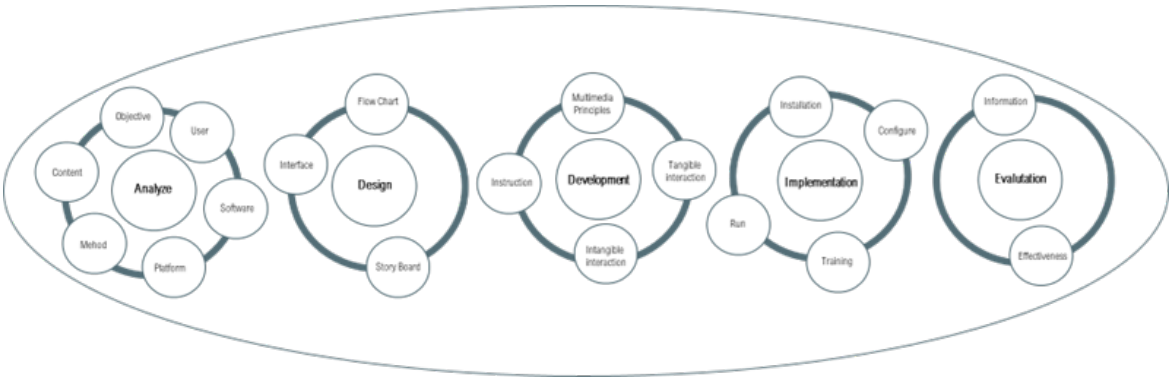

Fig. 2. m-ADDIE Model [34]

Analyze: The analysis phase was carried out to identify i) objective, ii) user, iii) content iv) method and iv) platform and software for the development of an introductory learning module to the Internet of Things at Community College through the scouting method. In this phase, an interview survey of 3 lecturers and course planners to find out the extent to which the module requirements in teaching meet the current requirements of Introduction to the Internet of Things at Community Colleges. The conclusion from the needs analysis proves that there is still a gap in the implementation of the teaching and learning course Introduction to the Internet of Things at this Community College.

Design: Through the design phase, visual representations in more detail such as flowcharts, interfaces and storyboards can be used as a guide in determining the lesson plan in the development of this learning application.

Development: The development phase is the application development phase based on the decisions from the design phase. In the development of this learning application, the development phase involves four sub-tasks namely: Multimedia principles, tangible interaction, intangible interaction and instructions.

Implementation: The implementation phase is the phase of implementing and testing the module prototype that has been fully built. Through this phase, the module is tested for functionality and analyzed from the installation, training and implementation of the actual module and application through the validation and pilot study. This phase is important to ensure that the objective of the development is achieved.

Evaluation: The last phase involves the evaluation phase of the application that has been developed. The effects of this AR-MicroC Microcontroller are evaluated through achievement tests to see student achievement after using this learning module and apps. The achievement test involves a pre-test and a post-test conducted on 66 respondents from a selected sample.

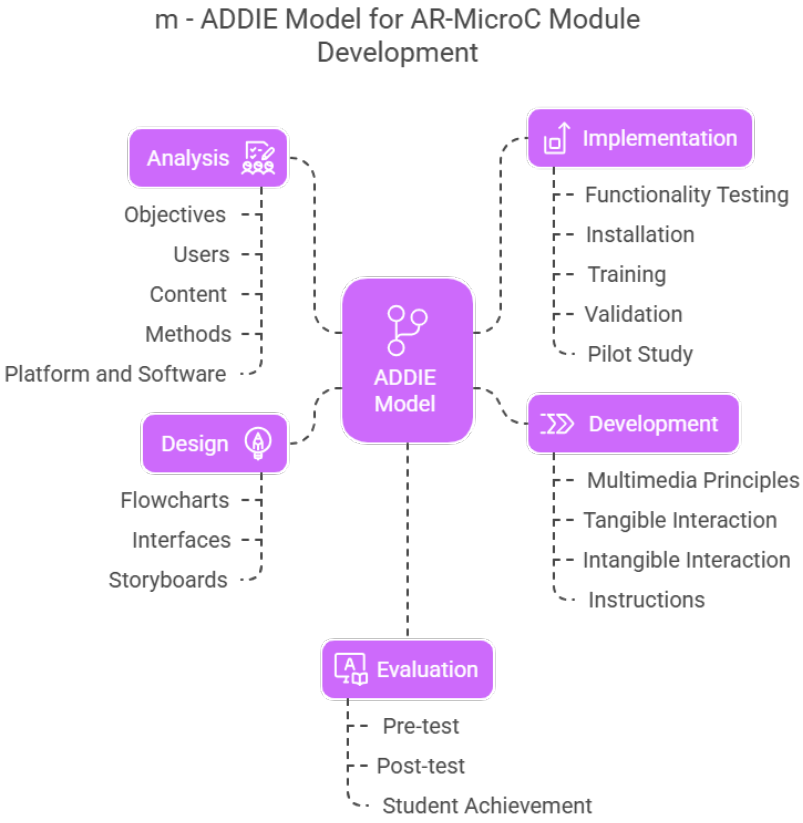

Fig. 3. m-ADDIE Model for AR-MicroC module development

The AR-MicroC innovation product was developed as the main module in learning Introduction to the Internet of Things. The module is developed as a physical module through the publication (ISBN 978-629-7524-83-2) of a book titled "Modul Mikropengawal AR-MicroC" and an AR-MicroC mobile application that uses Augmented Reality technology that can be download through Google Playstore as in Figure 4.

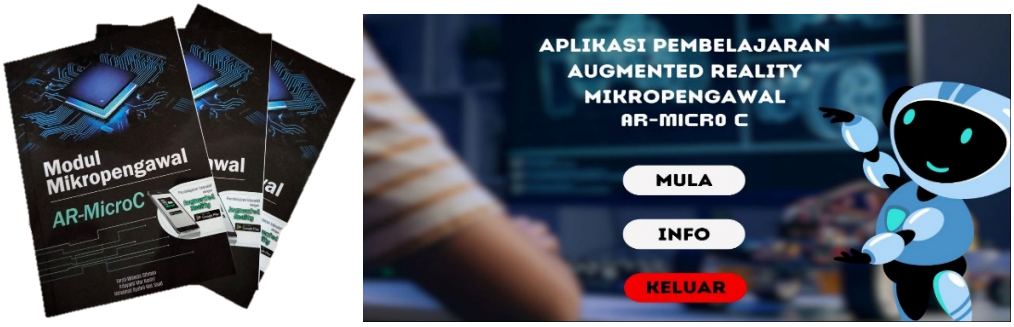

Fig. 4. AR-MicroC module and application

3.2 Validity

The validity of the module is very necessary so that the built module helps students master the stated objectives. The content validity questionnaire of this research module was adapted from Sidek and Jamaludin [35]. The questionnaire used contains 5 question items and is in the form of a five-point likert scale. The questionnaire also contains a comment column at the bottom of the questionnaire to allow experts to give their views on the content of the module. With that, the researcher can refer to the room to strengthen and strengthen the activities of the module. According to Mullen [36], seven (7) experts are sufficient, while Giannarou and Efthimios [37] suggests seven (7) to 10 experts. So, in this research, the researcher chose nine experts based on their expertise in the field under study. Their feedback and views have been considered in the improvement of the learning module prototype. Apart from that, the value of validity was also found because of their response to the questionnaire given. Apart from the selection of the number of experts, the researcher ensures that the selected experts have experience and background in the field related to the study so that there is no weakness in the accuracy of the results [37]. Table 1 shows the expert selection criteria for bounded validity.

Table 1
Expert selection criteria

Expert type	Expert Selection Criteria
Face Validity (Language)	Professionals working as lecturers teaching Malay or National Language subjects for more than 10 years. Have at least a degree in Malay Studies
Content Validity (Curriculum)	Professionals who work as lecturers and have teaching experience in the field of Information Technology or more than 10 years. Posses at least a degree in Information Technology or equivalent.
Technical and Multimedia Validity (Design)	Professionals who have background, training, knowledge and experience in either the field of Information Technology, Multimedia, Educational Technology or Instructional Media for more than 10 years.

To obtain content validity, a specific formula is used, i.e. the total score filled in by the expert (x) will be divided by the total score (y) and multiplied by one hundred. According to Sidek and Jamaludin [35], instruments with high validity when obtaining 70% are considered to have mastered or reached a high level of achievement or have good validity. The formula used is as follows:

$$\frac{\text{score filled in by the expert (x)}}{\text{total score}} \quad X \quad 100\% = \quad \text{Content Validity}$$

3.3 Realiability

The reliability questionnaire of this module was constructed by referring to Sidek and Jamaludin [35]. The items in the module reliability questionnaire created based on the activity steps in the module are better for determining the reliability of the module compared to the items created based on the objectives of the module [35]. So, the researcher adapted each item to the activity in the module reliability questionnaire based on the activity step in the AR-MicroC Augmented Reality Learning Module. To find out the reliability level of the module, the Cronbach Alpha coefficient method is used to determine the reliability value of the module to be developed. The value of the reliability coefficient or Cronbach Alpha obtained from the results of the pilot study and the actual study was analyzed and compared with the Table of Reliability Values [39] as in Table 2.

Table 2
Reliability Values

Reliability coefficient	Reliability Value
0.8 to 1.0	Very good and effective with a high level of consistency
0.7 to 0.8	Good and acceptable
0.6 to 0.7	Acceptable
<0.6	Item needs to be repaired
<0.5	Items need to be dropped

4. Results

4.1 Validity

Validation of the module is carried out against aspects of language, content, and technical and multimedia design. Questionnaire instruments were used to obtain validity from 9 experts appointed according to their respective fields. A total of one (1) expert in the field of language, five (5) experts in content, and three (3) experts in technical and multimedia design have been appointed based on the criteria that have been set. Table 3 shows the profile of experts who have been appointed to assess the validity of the AR-MicroC Augmented Reality Learning Module.

Table 3
AR-MicroC Microcontroller Learning Module validation expert profile

Experts	Background and Experience
Language Expert	Senior Lecturer and Head of General Studies Unit, Community College National Language Curriculum Drafter for the Department of Polytechnic and Community College Education (JPPKK) Graduation of Education Degree (Teaching Malay as First Language, UPM) 15 years of teaching experience
Content Expert 1	Senior Lecturer, Faculty of Electronics and Computer Technology and Engineering Graduation of Doctor of Philosophy (Computer Engineering), UTEM 22 years of teaching experience
Content Expert 2	Principal Lecturer, Information Technology Programme, Community College. Curriculum Drafter for *STM30273 Introduction to Internet of Things course,* Certificate in Information Technology, Department of Polytechnic and Community College Education (JPPKK) Graduation of Bachelor's Degree in Information Technology 21 years of teaching experience
Content Expert 3	Senior Lecturer, Information Technology Programme, Community College. Graduation of Bachelor's Degree in Information Technology 17 years of teaching experience
Content Expert 4	Senior Lecturer, Information Technology Programme, Community College. Graduation of Master's Degree in Technical and Vocational Education 15 years of teaching experience
Content Expert 5	Lecturer, Information Technology Programme, Community College. Graduation of Bachelor's Degree in Information Technology 15 years of teaching experience
Design Expert 1	Senior Lecturer, Department of Creative Multimedia, Faculty of Arts, Computing and Creative Industries, UPSI Approval of Doctor of Philosophy (Multimedia), UPSI 10 years of teaching experience
Design Expert 2	Principal Lecturer, Community College Graduation of Doctor of Philosophy (Instructional Technology), UPSI 19 years of teaching experience
Design Expert 3	Lecturer, Department of Information and Communication Technology, Polytechnic Graduation of Doctor of Philosophy (*Game Based Learning*) UPSI 15 years of teaching experience

The results of the expert assessment are as follows in Table 4, Table 5 and Table 6:

Table 4
Validity of language assessment for AR-Microcontroller Augmented Reality Module

	Item	Expert	Assessment Interpretation
1.	The font size is easy to read and clear.	100	Good
2.	The font used is appropriate.	100	Good
3.	Use text features such as 'bold' and 'italic' to grab attention.	100	Good
4.	Text is free of spelling errors.	100	Good
5.	The use of language is clear, precise and easy to understand.	100	Good
6.	The words used are correct.	100	Good
7.	The sentences used are easy to understand.	100	Good
8.	Correct and clear sentence order.	100	Good
9.	This way of writing modules is suitable for lecturers and students.	100	Good
10.	The language used is appropriate to the level of lecturers and students.	100	Good
	Overall Average Volume	100	Good

Table 5
Validity of content assessment for AR-MicroC Augmented Reality Learning Module

	Item	Expert					Average	Assessment Interpretation
		1	2	3	4	5		
1.	The content of this AR-MicroC Module meets its population target	100	100	100	100	100	100	Good
2.	The contents of this AR-MicroC Module are perfectly executable	100	80	80	100	100	92	Good
3.	The contents of this AR-MicroC Module correspond to the allotted time.	80	80	80	100	100	88	Good
4.	The content of this AR-MicroC Module can improve student performance.	100	100	100	100	100	100	Good
5.	The content of this AR-MicroC Module can change students' interests in a more outstanding direction.	100	80	80	100	100	92	Good
	Overall Average Volume						94	Good

Table 6
Validity of design (multimedia and technical) assessment for AR-MicroC Augmented Reality Learning Module

	Item	Expert			Average	Assessment Interpretation
		1	2	3		
1.	The AR-MicroC module can be easily downloaded and achieved.	100	80	80	87	Good
2.	The AR-MicroC module works well.	100	100	100	100	Good
3.	The AR-MicroC module has a smooth transition from single display to display other.	80	100	100	93	Good
4.	The button of each transition works well.	80	100	100	93	Good
5.	Audio and video that are clear and appropriate to the target population.	100	80	80	87	Good
6.	A clear diagram and in accordance with the target population.	100	80	100	93	Good
7.	Text that is clear and appropriate to the target population.	80	80	100	87	Good
8.	Clear and uniform font size.	100	80	100	93	Good
9.	Diverse and interesting fonts.	80	80	100	87	Good
	Overall Average Volume				91	Good

According to Sidek and Jamaludin [35] a validity of 70% and above has achieved a high level of achievement or has good validity. This means that the findings from the validity of the modules that have been implemented show that the AR-MicroC Augmented Reality Learning Module is in line with the credibility of its development. However, there are comments and views or ideas from experts for improvements to further strengthen this module. Overall, based on the feedback from the evaluators on the AR-MicroC Augmented Reality Learning Module, it shows that this module meets the objectives and goals that have been set.

4.2 Reliability

The AR-MicroC Augmented Reality module has been tested for reliability after obtaining expert validity, to ensure that its activities can be adopted in the long term. In addition, it is hoped that the activities in this module will also be able to provide changes to students, especially in terms of achievement and motivation. In this study, the activity reliability coefficient of the AR-MicroC

Augmented Reality Learning Module was tested using question items constructed based on the module's activity objectives. This decision was chosen because the construction of activity-based questions was perceived to be easier [35]. These questions are then handed over to students to answer once they have completed each activity in the AR-MicroC Augmented Reality module. The results of Alpha Cronbach's analysis show that the overall reliability value of the AR-MicroC Augmented Reality Learning Module activity is very good, with a value of 0.952. Table 7 shows the reliability values of the module.

Table 7
Module reliability values

Content Standards	Activity Module	Reliability Values	Interpretation
Introduction to the Internet of Things	Activities 1 and 2	.711	Good
Microcontroller / IoT Board	Activities 3 and 4	.773	Good
Electronic Components	Activity 5	.738	Good
Sensors	Activity 6	.921	Excellent
Power Supply	Activity 7	.872	Excellent
Motor and Actuator	Activity 8	.915	Excellent
Raspberry Pi circuit connection	Activities 9 and 10	.939	Excellent
Arduino circuit connection	Activities 11 and 12	.968	Excellent

Overall, this AR-MicroC Augmented Reality Learning Module has high reliability. The Alpha Cronbach value calculated based on the sub-content also shows excellent and good reliability values. This means that the content of the module's activities can be used and is also ready to be tested in terms of its impact on student achievement.

5. Discussion

The validity of the modules is important to ensure that the develop module help students master the objectives that have been set. The assessment of the validity of the module measures the extent to which the module can achieve the desired goal [35]. According to Sidek and Jamaludin [35] and Tuckman and Brian [40] when a module reaches or exceeds the level of comprehension or achievement by 70%, it is considered to have reached a high level of achievement or mastery of the learning module. In this context, a module is considered quality if it can effectively measure all its content, demonstrating a good level of content validity [41]. The data shows that the average percentage of the minimum item is 87% and the maximum percentage is 100%. The average agreement of the nine experts on the language, content, and technical design was 100%, 94%, and 91%, respectively. When the validity value of each item exceeded 70%, it showed good validity of the content of the AR-MicroC Augmented Reality Learning Module developed [42,43].

The module reliability assessment was carried out through a pilot test to 29 students in semester 3 who took the STM30273 Introduction to Internet of Things course. The aim was to assess the suitability of the modules used before they were used in the actual study. However, future research should consider using a larger sample size to increase the validity and generalizability of the findings. The reliability questionnaire of this module was constructed by referring to Mohamad Ali [34]. The data shows that the value of Alpha Cronbach's coefficient is at a very good level with a value of 0.952 (α=0.952). Every item or sub-content in the module activity is also at a good and very good level. Learning modules that have high reliability are also considered to explain students' perceptions in determining their acceptance of the modules developed [44]. The high reliability value also indicates that the module activities are systematically aligned with the intended learning outcomes, such as enhancing students' understanding of Internet of Things (IoT) concepts, improving engagement, and

developing relevant technical skills. The consistency in responses across module items suggests that students interpret and engage with the content in a meaningful and uniform manner. This provides valuable insights into the readiness of the AR-MicroC module to be implemented in actual teaching scenarios, where it has the potential to positively impact student achievement and learning experiences. The reliability assessment of the module has also been carried out by previous researche [12,44,45].

6. Conclusion

In conclusion, the AR-MicroC Augmented Reality Learning Module has demonstrated a high level of validity and reliability, ensuring its effectiveness as a learning tool. The module's content validity was verified with expert evaluations, achieving an average agreement of 100% in language, 94% in content, and 91% in technical design. All items surpassed the 70% threshold, with some reaching up to 100%, affirming the module's strong content alignment with the learning objectives. Furthermore, the pilot test conducted on 29 students yielded a Cronbach's Alpha coefficient of 0.952, indicating excellent reliability. This suggests that the module is well-structured and well-received by students, making it a dependable resource for enhancing mastery of Internet of Things concepts. Ultimately, the AR-MicroC module proves to be an asset in achieving educational goals in line with current technological advancements. Overall, the two objectives of the study were achieved. The AR-MicroC Augmented Reality Learning Module can be used as fuel based on the validity and reliability of the modules that have been evaluated in this study. It is hoped that the development of the AR-MicroC Augmented Reality Learning Module has made a scientific contribution, especially to students, lecturers, curriculum divisions, and related parties in improving the achievement of this technology not only to increase the achievement of student understanding, but it also has a positive impact on the motivation element of students in learning the concept of Microcontrollers.

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