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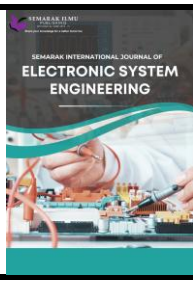

The Development of Augmented Reality Application in Electronic Design Topic Under Design and Technology: Application Design Validation

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ABSTRACT

The evolution of education has brought significant transformation of Teaching and Learning (T&L) sessions with technologies and digital products, offering students engagement with new learning experiences. This change leads to the change of curriculum of education in Malaysia especially in technical and vocational subject. Design and Technology (D&T) is one of the newest subjects which is replaced from Integrated Life Skills. There are multiple studies shows electronic topic is one of the hardest topics in D&T which leads to difficulty of students to reach their highest mastery level in Curriculum Standard and Assessment Documentation (DSKP). The teachers and students do not have enough time to build electronic project due to their lack of technical skills and poor visualisation effect of students. This purpose of this study is to design and develop Augmented Reality (AR) application in electronic topic and validate the application design validity among experts. This study uses qualitative research design with the help of model ADDIE approach which focuses more on design, development, and implementation phase. The design and development of application uses main theories which are Multisensory Learning and Mayer's Cognitive Theory of Multimedia Learning with the help of navigation map, wireframe, and storyboards. After design and development phase, the application design will be validated by three experts who are in Information Technology, and Computer Science field by using questionnaire. There are 12 items in questionnaire to validate the application design validity. The data of the study is analysed by using Content Validity Index (CVI). The result of CVI value for all items are 1.00 and the value of S-CVI is 1.00. This shows the application design validity can be used in pilot study and actual study to see the usability or effectiveness of the application. In conclusion, application design had been validated by experts which could enhance the quality of application design and find the gaps of the research in future studies which are findings its usability and effectiveness of the application.

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1. Introduction

The evolution of education has brought significant transformation of Teaching and Learning (T&L) sessions with technologies and digital products, offering students engagement with new learning experiences. There are multiple studies performs T&L sessions in this era of education due to existing to 2-Dimensional (2D) Simulation Artificial Intelligence (AI), Augmented Reality (AR), Virtual Reality (VR), and Holograms. According to Khalid *et al.,* [1] literature review, digital learning which offers interactive and immersive T&L can enhance students' enrichment of new knowledge, and improve their competencies and motivation such as digital simulations, virtual laboratories, and interactive multimedia resources. This paper aims to develop and validate the application development of Augmented Reality in Electronic topic under Design and Technology (D&T) Subject. A study from Arshad *et al.,* [2] had discovered D&T is one of the newest subjects which was replaced from Integrated Life Skills in 2017. This is based on Oliva [3] which shows that the curriculum will always change based on 10 axioms. The changes of concurrent changes of time with advances technologies had change curriculum in Malaysia to develop young generations with creative, innovative and critical-thinking skills to achieve the workforce based on Industry Revolution (IR) 4.0.

D&T subject is one of the newest subjects in primary and secondary school which aims to develop students' potential of comprehensive, creative, and innovative students to create product based on their knowledge in D&T subject. Although the aims of D&T can build and enhance students critical thinking through the product development, there are some issues and challenges encountered during T&L session. According to Sahaat and Nasri [4] questionnaires data, the teachers claim that the efficiency of time in electronic topic is not enough to develop a project. Other than that, Idris *et al.,* [35] claims that the electronic topic teachers are lacking of technical skills while Jafini *et al.,* [5] claims that could not visualise the interconnection of electronic components and microcontroller which makes them struggle to build electronic project. This article has been supported by Othman *et al.,* [6] and Liono *et al.,* [7] which supports the needs of visualisation effect of students to build electronic projects. There are multiple studies of needs analysis in D&T [2,4-12,35] shows the challenges and needs from teachers' and students' perspectives.

Although, there were multiple studies of electronic topic in D&T subject but the application visualisation effect through Multisensory Learning and Mayer's Cognitive Theory of Multimedia Learning (CTML) have not to be discovered from previous studies. Therefore, this study focuses more on the design and development of AR application and the application design validity before conducting pilot study and actual study. There are multiple research gaps who have yet to discover the validity of application design. The instrument of MAG mobile application from Llorens-Vernet and Miró [30] study have not yet validate the application design validity which shows the user to attract interest and interact towards the application. According to Wang [31], the mobile applications should be interactive which apply the connection, engagement, and participation of user to use the mobile application. Therefore, this study focuses to find the gaps of the application design validity among experts to ensure the application design had made by the researcher can interact user to use the application in the future study.

2. Literature Review

The theoretical framework is based on two theories in design and development phase which are Multisensory Learning and CTML where both theories are used to create an interactive module to give excitement and enjoyable of learning for students during T&L sessions. Figure 1 shows the theoretical framework of the study to develop module based on the theories.

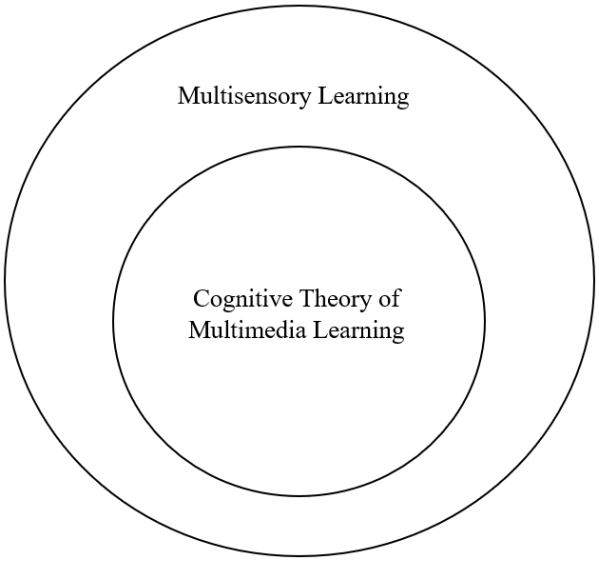

Fig. 1. The theoretical framework in design and development phase

There are three types of learning for the students to understand during T&L sessions which are audiology, visualization, and kinaesthetic in Multisensory Learning. According to Baberwal *et al.,* [13] study, the power of imagination would help a person to perform the strength of imagination which is called as Motor Imagery (MI). This study also explains the used of virtual reality which enhance user MI through audio and screen. Other study from Muda *et al.,* [14] had discovered interactive tool to learn with the used of Arduino-based system which help the students to enhance their kinaesthetic learning style during T&L sessions. According to Siagan and Syahril [15], students tend to engage during T&L session visualization effect occurred. This statement had shown that students tend to use 75% visual senses, 13% auditory senses, and 12% from other senses such as touching senses. Therefore, it is important to integrate audiology, visualization, and kinaesthetic learning to motivate and enhance their knowledge [15] in electronic topic under D&T subject. This study focuses more on the use of Multisensory Learning with the help of AR to attract the interest of students during T&L session.

There are multiple studies integrate CTML during T&L sessions with Multisensory elements. According to Spaccarotella *et al.,* [16] study, the use of CTML can enhance visual and auditory information to user which reduces the cognitive load which only shows the preparation of food through QR code. Other study from Karim and Karim [17] had shown that CTML in AR can be helpful to increase students' knowledge in Gravitation topic which shows the positive impacts through tests. This study shows the effectiveness of AR in Gravitation topic with implementation of CTML gives students meaningful experience during T&L sessions. According to Kuba *et al., [*18], the CTML is suited to be implemented into practice to grow and respond during learning and instruction environment. Thus, this would help the user to learn a valuable knowledge through Mayer principle which could reduce the cognitive load of user [18]. This study focuses more on the use of CTML with the help of AR to engage students with the interactive ways of learning during T&L sessions.

3. Methodology

3.1 Research Design

This study was conducted by using quantitative research design with the help of Analysis, Design, Development, Implementation, Evaluation (ADDIE) Model approach from Hashim *et al.,* [19] which

focuses more on Design, Development and Implementation. A study from Fajarini and Rahayu [20] shows quantitative research design can be done by using questionnaires to validate the validity of instruments. A study from Aithal and Aithal [36] had discovered that questionnaire is widely used in social science to collect quantitative data from participants in related field. According to Diputera *et al,.* [21] shows the application a set of questions on application design is validated by three experts. Therefore, this application in this study is validated by using questionnaires. Figure 2 shows the ADDIE Model phases in this study.

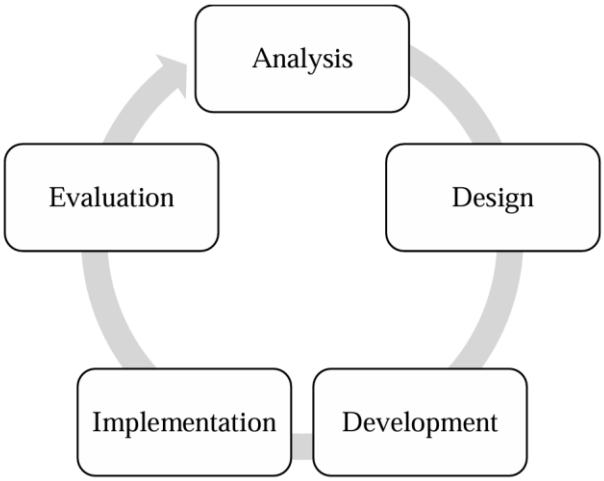

Fig. 2. The ADDIE model

The triangulation of this study consists of document analysis, interview session and application design validity questionnaire. According to Bans-Akutey and Tiimub [37] study, triangulation of the study is important to increase the credibility and validity of the study which shows that multiple approaches to extract the information in the study. The document analysis, and interview session had been conducted during analysis phase by Jafini *et al.,* [5] which the researcher had found out the challenges and needs in electronic topic. There are several resources needed to be included to solve the challenges in electronic topic. Figure 3 shows the resources needed in electronic topic.

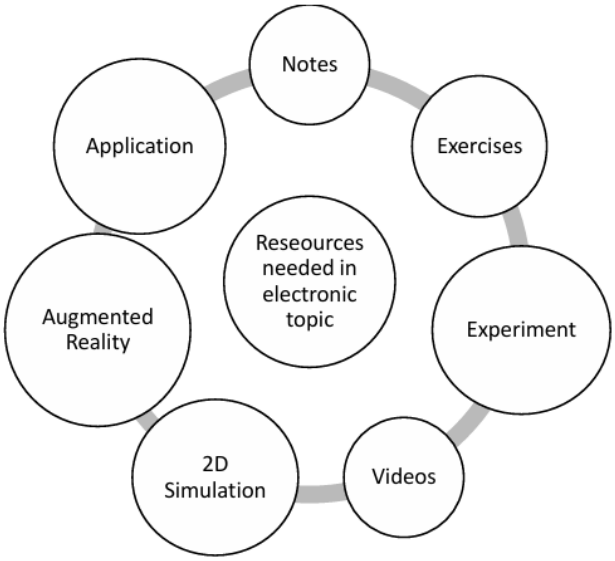

Fig. 3. The resources needed in electronic topic

According to Jafini *et al.,* [5], the resources needed in electronic topic are notes, exercises, experiment, videos, 2D simulation, Augmented Reality and application. Therefore, the researcher gets the initiative to develop application with integrated AR application in electronic topic. This paper focuses more on the design and development of application, and application design validity with the adaptation from Mohamad Ali [22] and Diputera *et al.,* [21] respectively. The design and development of application was conducted during design and development phase while the application design validity was conducted during implementation phase.

After design and development of application, the application must be validated before conducting pilot study and actual study. According to Schaufeli *et al.,* [32] the instrument of the study must be validated to get the value of validity before conducting reliability test or pilot study. A study from Sürücü and Maslakçi [34] stated that the purpose of application design validity is a measurement of quality to measure the instrument performances of its function. Thus, this study focuses on the validity of application design to strengthen the performance of application.

3.2 Application Design and Development

The designs of the application are based on two theories which are Multisensory Learning and Mayer's Cognitive Theory of Multimedia Learning (CTML). The theories are implemented into the application which explains the needs of visualisation effect of students with integrated AR. The design application used during development of AR are Blender and Unity 3D to create the application with the help of Mohamad Ali [22]. According to Mohamad Ali [22], the development of application needed to be conducted step-by-step where the application navigation map, wireframe, and storyboards needed to be designed before developing application. Figure 4 shows the navigation map of application.

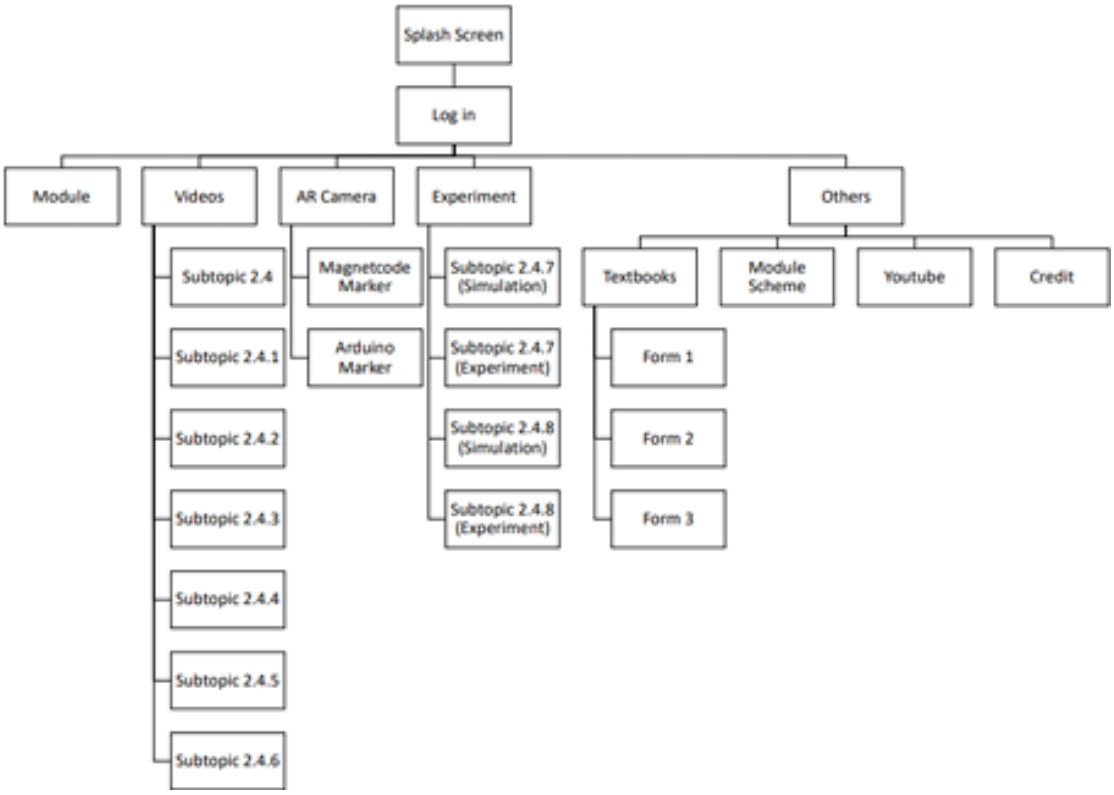

Fig. 4. Application navigation map

Figure 5 shows the wireframe of application, while Figure 6 shows the elements of Magnetcode and Arduino AR through wireframe and storyboards.

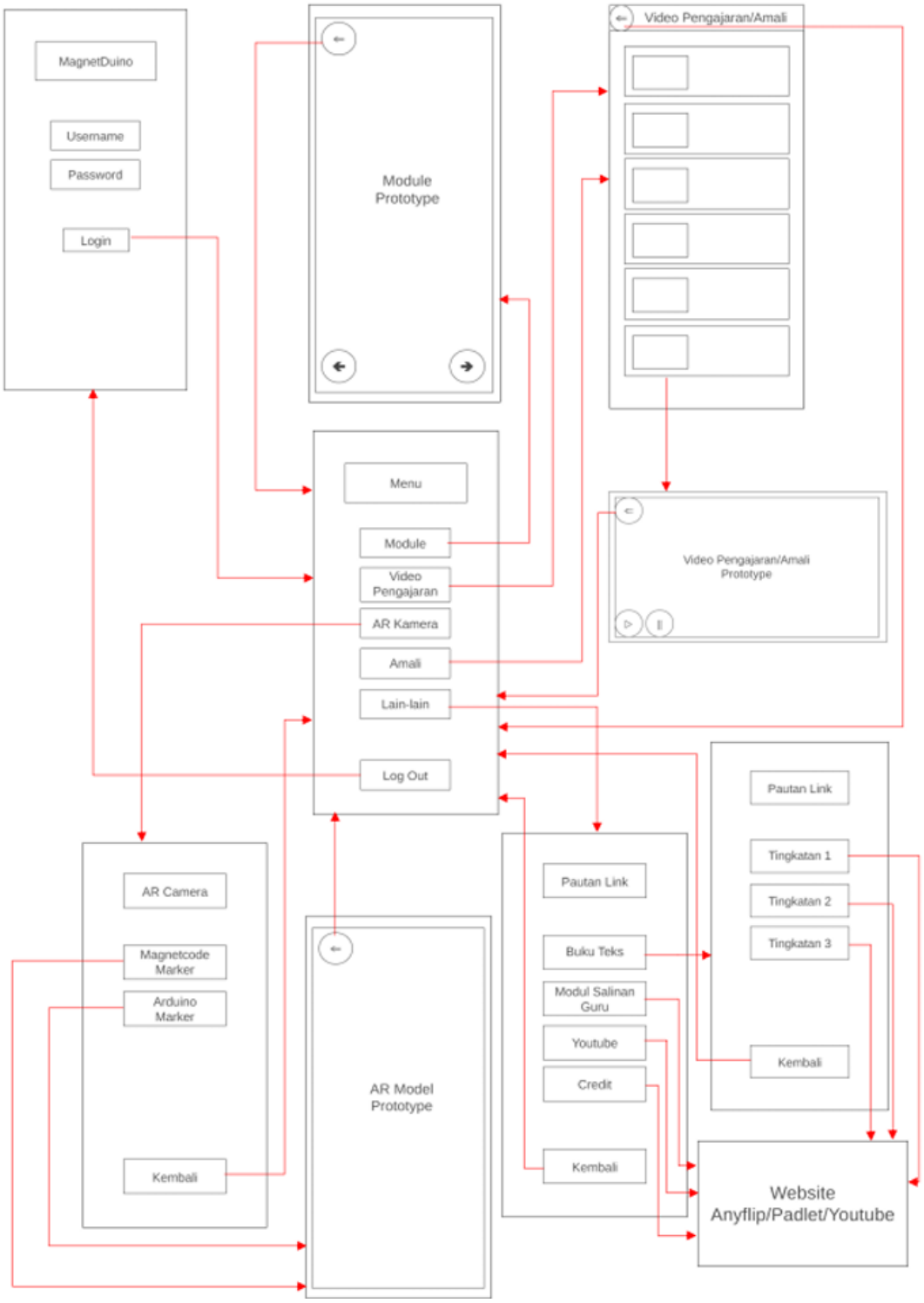

Fig. 5. Application wireframe

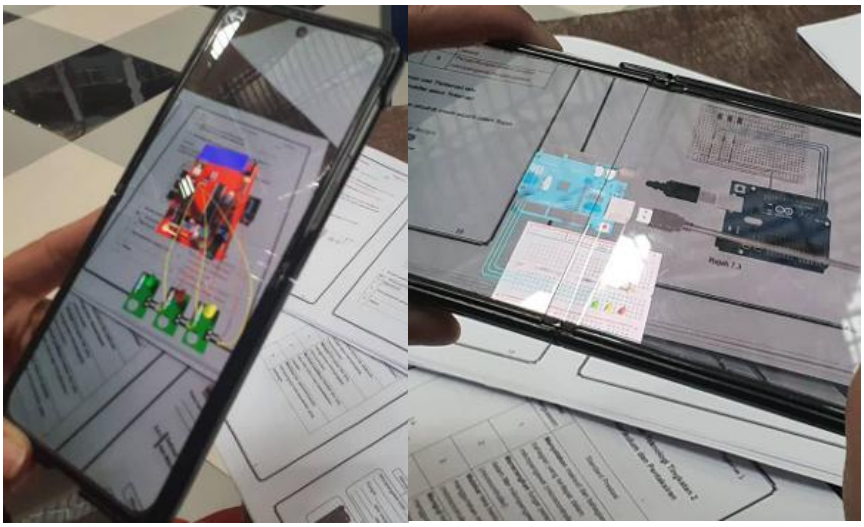

Fig. 6. Elements of Magnetcode and Arduino AR through wireframe and storyboards

3.3 Validation Instrument and Sample

The questionnaire is used as validation instrument for the experts to validate the application design. The instrument is adapted from Ismail [23] where the instrument had been prepared based on application design needs before giving it to the experts. The every of all item were validated by using five Likert Scale which "1" indicates strongly disagree, "2" indicates disagree, "3" indicates uncertain, "4" indicates agree, and "5" indicates strongly agree. Table 1 shows the items of application design validity instrument.

Table 1
The items of application design validity instrument

The items	The content of application design validity
Item 1	The application can be downloaded and easy to access.
Item 2	The function of application is working well.
Item 3	The application has smooth transitions from one screen to another.
Item 4	The buttons for each transition function properly.
Item 5	The audio and video are clear and suitable to be used by students and teachers.
Item 6	The diagrams are clear and appropriate as reference for students and teachers.
Item 7	The text is clear and suitable to be viewed by both students and teachers.
Item 8	The font is clear and consistent.
Item 9	The fonts are diverse and attractive.
Item 10	The image verification of AR if functioning well.
Item 11	The interactive multimedia is engaging and suitable to be used by students and teachers.
Item 12	The interactive multimedia is engaging and have the capability to capture interest of students and teachers.

The validation sample of application development is chosen by using purposive sampling technique. According to Susantini *et al.,* [24] study, there are three experts selected in the validation process on android-based higher order thinking skill assessment. A study from Effendi and Khairani [25] had selected experts with experience of more than 3 years in their fields. Therefore, the researcher selected three experts with experience of more than three years to validate application design validity of application. The selection of experts must be in Information Technology, Computer Science or Technology field which they can express their school of thoughts or expertise in application

design validity. According to Saaty and Ödzemir [33], the selection of experts must be in related field and have experience in programming language which would leads to no weaknesses of accuracy of validity based on the result of this study. The Table 2 shows the background of experts.

Table 2
The background of experts

The experts	Education Background	Experience in Information Technology and Computer Science	Expertise in application design
Expert 1	Bachelor's Degree (Honoure) in Science Education Master's Degree in Computer Science Education	8 years	Application designation, and programming language
Expert 2	Bachelor's Degree in Information Technology with Honours	16 years	Mobile application designation, augmented reality build and programming language
Expert 3	Bachelor's Degree Technology in Education (Building Construction) with Honours	3 years	Application designation, 3D model designation, and programming language

3.4 Data Analysis

The data was analysed by using content validity index (CVI) with the adaptation from Yusoff [26] rule of thumb. Table 3 shows the number of experts and its implication on the acceptable cut-off of CVI as a scale of application design validity.

Table 3
The number of experts and its implication on the acceptable cut-off score of CVI from Yusoff [26]

Number of experts	Acceptable CVI values	Sources
Two experts	At least 0.80	Davis [27]
Three experts	At least 1.00	Polit *et al.,* [28]
At least six experts	At least 0.83	Polit *et al.,* [28]
Six to eight experts	At least 0.83	Lynn [29]
At least nine experts	At least 0.78	Lynn [29]

The data of validation were converted into "0" and "1" where the 1-3 Likert Scale indicates as "0" which is disagree while the 4-5 Likert Scale indicates as "1" which is agree. This CVI value and S-CVI value were analysed according to this formula which are:

$$\mathrm{CVI} = \frac{\text{The expert in agreement}}{\text{The number of experts}} \tag{1}$$

$$\mathrm{S-CVI} = \frac{\text{The average of CVI scores across all items}}{\text{Total of items}} \tag{2}$$

Therefore, the CVI values can determine the validation or the strength of the application design by three experts. Therefore, the CVI values needed to be obtained in the study must be at least 1.00 from the adaptation of Polit *et al.,* [28] before conducting pilot study and actual study.

4. Result and Discussion

The data of validity is collected and analysed through CVI which the CVI value but be above 1.00 and the S-CVI value at least 0.80. The results indicated that all three experts unanimously agreed on 12 items, each achieving score of 1.00. The items of CVI denoted 1.00 which shows excellent and recommended by scholars Polit *et al.,* [28]. The value of S-CVI score 1.00 which shows the all of the items can be accepted and valid to be used in pilot study and actual study. Table 4 shows the validity of application design by experts.

Table 4
The validity of application design

Items	Experts			CVI	Interpretation	S-CVI
	1	2	3			
Item 1	1	1	1	1.00	Acceptable	1.00
Item 2	1	1	1	1.00	Acceptable	
Item 3	1	1	1	1.00	Acceptable	
Item 4	1	1	1	1.00	Acceptable	
Item 5	1	1	1	1.00	Acceptable	
Item 6	1	1	1	1.00	Acceptable	
Item 7	1	1	1	1.00	Acceptable	
Item 8	1	1	1	1.00	Acceptable	
Item 9	1	1	1	1.00	Acceptable	
Item 10	1	1	1	1.00	Acceptable	
Item 11	1	1	1	1.00	Acceptable	
Item 12	1	1	1	1.00	Acceptable	

The results of application design validity items are validated by three experts which is valid and accepted to be used in pilot study and actual study. The navigation button and application are smooth to be used and the application is easy to access. These items would be convenient for teachers and students to learn and teach electronic topic which is suitable to be used in class. Other than that, the audio is clearly to be heard while the diagrams, and videos is clearly visible to be seen by user. This would enhance the students' audiology effect and visualisation effect through Multisensory Learning by using CTML. The AR marker can be detected and it is visible and interactive for user to learn during T&L session and build electronic topic project. This would enhance students' visualisation effect and kinaesthetic practically through AR which with the help of CTML. Thus, this application can be used in D&T subject which could enhance students' and teachers' competencies in D&T subject in future studies. This study concludes that the application is suitable to be used which would engage the students' interest to learn new knowledge in electronic topic. Thus, these items of application design and user interaction are valuable to make sure that the quality of application is interactive that can be used by user.

However, the AR application in electronic topic needed to be improved according to the experts. Table 5 shows the comments of experts to improve the quality of the AR application.

Table 5
The comments of experts to improve the quality of the AR application.

The experts	Comments of improvement
Expert 1	Adding the element of gamification such as simple quizzes based on the subtopic which they learned.
Expert 2	The videos can be improved by adding text of explanation in videos for students easier to understand. There are some smartphones does not support AR Camera which is Apple product.
Expert 3	Adding zoom in and zoom out features in the application which leads to accuracy of reading.

The purpose of getting comments of improvement to enhance the quality of application where the researcher can modify and customize interactive application for the user to learn electronic topic. According to the expert 1, the element of gamification is important to get attention of students to engage more during teaching and learning session. According to Denny [38], Kuo and Chuang [39], and Gündüz and Akkoyunlu [40] had discovered that gamification gave positive effect on students' academic achievement to enhance their quality of competency. Other than that, the expert 2 claims that the videos in the application needed text to avoid misunderstanding from students especially who have hearing problems. The expert 2 also claims that, the application needed to be further improved where the application must be supported by Apple product as well. Lastly, the expert 3 leave a suggestion where adding zoom features can leads to accuracy of reading for the students who have visual problems. Therefore, the application design needed to be further improved by adding features in the application which had been suggested from the experts.

5. Limitations and Future Studies

Although the application had been validated by the experts but there are some limitations in this study. The purpose of this paper is to validate the validity of application design to find the gaps of study in electronic topic. The study consists of three experts to validate application design validity which requires the CVI value of 1.00. The researcher suggests to validate the application design above nine experts which requires the CVI value of 0.78. This would give more accuracy in validation and various kind of comments and opinions to enhance the quality of the application design. This application design and development is limited which focuses on electronic topic in D&T subject to enhance the visualisation effects of students during teaching and learning session. Therefore, the researcher suggested that the application can be used by other user as well which have relation to electronic, microcontroller, and programming language. Other than that, the contents of application have not yet to be discovered by the researcher where most of the content in the application have relation with electronic, microcontroller, and programming language. Thus, the content validity of application needed to be validated as well in future studies to discover the suitability of content in the application.

6. Conclusion

The conclusion of this study is to examine the validation of application design development integrates with the use of AR in Electronic topic. The application is designed and developed with two theories which are Multisensory Learning and CTML. This would reduce the cognitive loads of students which could increase their visualisation effect by using Multisensory Learning during teaching and learning session. The application is developed with the guidance of Mohamad Ali [22] which helps the researcher to develop a systematic development of application. This would enhance the quality of application that helps the students to understand with interactive and enjoyable environment. Research findings indicate the application design validity for students and teachers to use whether the application can be used by students and teachers during T&L session. All of the items are validated and accepted by three experts with the value of CVI 1.00 and S-CVI 1.00. Thus, the items are acceptable and valid to be used in the study. Therefore, the objective of the research which is to develop the application based on objectives had been achieve and the application design of AR application had been validated. In futures studies, the researcher can find the effectiveness or usability of application among students or teachers, and find its motivation or interest among students or teachers.

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