Development of ARcell Apps for The Topic of the Structure of Cells and Organelles

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Abstract

This research aimed to develop and evaluate the level of usability of Augmented Reality apps named ARcell for the topic of The Structure of Cells and Organelles. The research design used was development research. The development of this ARcell apps was based on the ADDIE model, with the integration of Constructivism learning theory and Mayer Cognitive theory of multimedia learning. The validity of the ARcell apps was determined by experts, while the reliability was based on the pilot study. The level of usability of ARcell apps was determined through 101 Form 6 student's perceptions randomly selected from three schools in Malacca. The data were analyzed descriptively using the SPSS software. The findings showed that the ARcell mobile apps had good validity from the content aspect (S- CVI = 1.00), technical aspect (S-CVI = 0.97) and also had good reliability with Cronbach's Alpha value of 0.94 from the student's perspective. ARcell mobile apps also had good usability in terms of design, functionality, ease of use, learnability, satisfaction, future use, and system reliability, with a high mean value of 3.94. Essentially, the ARcell apps had good validity, reliability and usability and are very suitable for the use in the learning of Form 6 biology in the

topic of Cell Structure and Organelles. The implications of this study indicated that the ARcell mobile apps could be used as an additional teaching aid and can be a catalyst for a new global learning approach in Malaysia. It is very relevant and practical particularly in applying student self-learning during the country as well as the rest of the world facing the Covid-19 pandemic situation.

***Keywords**: Augmented Reality, Biology, Usability, education 4.0, ADDIE model, COVID-19*

INTRODUCTION

Based on the Malaysia Education Development Plan 2013-2025, the Ministry of Education Malaysia intends to use ICT equipment more effectively to provide teachers and students with additional information and resources. In Malaysia, 21st Century skills refers to skills and competencies in line with the National Education Philosophy that enables Malaysian students to compete internationally [1].

Today, the Industrial Revolution 4.0 (IR 4.0) has brought changes in various aspects of human life, including education [2]. The rapid innovation in innovation has delivered another education model for the future, namely Education 4.0 [3]. Anealka [4] said that the trends related to Education 4.0 implies that learning can be done anytime and anywhere. Besides, student learning can be focused on individuals and student-centred learning with the role of teachers as facilitators. Martin et al. [5] stated that various trends are emerging in education, referring to the needs of Industry 4.0, one of which is to use Augmented Reality (AR) as part of the modular learning system.

Nevertheless, teaching and learning entirely using mobile apps based on Augmented Reality (AR) is still not feasible in Malaysia. The AR apps is only made in certain sections of the students' textbooks. Students still need to rely on their textbooks to achieve the learning objectives of the topic.

The textbook loan scheme or known as "Skim Pinjaman Buku Teks" (SPBT) will also cause the marker card in the textbook to be damaged, torn or scratched due to the previous borrower, making it impossible to be scanned by the student's mobile phone camera to get the 3D-dimensional image display of the textbook AR[6].

Furthermore, students' difficulty in learning abstract concepts by visualisation is also one of the biggest problems of students in the subject of Biology. This problem persisted that many science stream students for Form 4 and 5 did not choose Science Stream in Form 6 because they were less interested in Science subjects such as Biology. Studying abstract Biology subjects is a significant challenge for Form 6 students who are generation Z.

Factors such as students' perceptions and concerns about low achievement as well as the difficulty of mastering science and mathematics concepts are among the reasons why students are less interested in choosing science streams. This thing is also often associated with methods and practices in the teaching and learning of science and mathematics, rigorous science assessment and difficulty in obtaining excellent results for the two subjects[7-9].

Using mobile technology and the subsequent visualisation of abstract concepts, we can make it easier for students to zoom in and demonstrate the subject matter of complex subjects. One of the methods of mobile learning that allow us to demonstrate the visualisation of a given subject is Augmented Reality [9]. AR is useful for making invisible contents visible and giving concrete examples for abstract contents in biology education. AR can minimize misunderstandings by students caused by inability to visualize a concept, provide visualization in detail and be able to give students a picture of an object that cannot seen with the naked eye. The use of AR in the process of learning biology, can helping students visualize difficult objects in the classroom teaching process [1, 10]. Besides abstract and complex information, cell biology covers many things that are too small to see with the human eye, such as protists and cells,

requiring special high-tech microscopes that are not affordable for schools[8, 11]. AR is useful for making invisible contents visible and giving concrete examples for abstract contents in biology education. AR also provides more accurate illustrations of too small or big subjects and too fast or long processes [4, 12].

According to Hoog et al.[13], the transition to remote education during the COVID-19 pandemic has necessitated additional means of providing classroom and laboratory content that is readily usable using devices accessible to students. In recent years, augmented reality apps have proven to be a powerful tool for three-dimensional model visualisation for teaching structural biology in smartphones near-ubiquitous devices.

Hence, this study was conducted to develop an Augmented Reality (AR) based mobile apps named ARcell for the subject of Biology Form 6 for the topic The Structure of Cells and Organelles. Therefore, the objectives of this study are:

1. To develop an ARcell mobile apps,
2. To determine the content and technical validity of ARcell mobile apps,
3. To determine the reliability of ARcell mobile apps, and
4. To evaluate the level of Usability of ARcell mobile apps from students' perceptions

LITERATURE REVIEW

According to [14], Augmented Reality (AR) will transform the educational landscape by allowing students to use mobile devices such as mobile phones or special AR glasses to use AR apps, in which students can view 3 Dimensional objects with pointing their mobile device to the AR marker. According to [15], the use of AR apps to teaching and learning in education has the following advantages i) interaction with students: concerning relatively tricky abstract concepts, students can repeatedly practice through an interactive operational process. AR can provide the correct concept knowledge can further enhance the comprehension abilities of its users. ii) establishment of spatial concepts: if the teaching material can make the concept of abstract space visible and visualise, it will provide significant benefits to students to promote their understanding of spatial concepts. The AR

materials developed are likely to transform abstract concepts into concrete and, thus, they can enhance the effectiveness of students' learning of spatial concepts.

Studies involving AR technologies are categorised into two classes. The first category is usability studies through existing apps on the Android platform, or IOS apps store such as Augment apps [13],[9, 16], Aurasma and other AR platforms. The second category is studies that construct their stand-alone apps using software such as Unity, Openspace3D, System Development Kit (SDK), Vuforia and others.

Researchers have identified several previous studies in the subject of Biology. According to the study of [17], it targeted Form 4 students taking Biology subjects. They developed an Augmented Reality-based mobile apps called ATTech System. This mobile apps is develop specifically for the topics of mitosis, meiosis and respiration. This study found that AR technology introduces new apps in increasing the effectiveness and attractiveness of the learning environment in real-time for students. Next,[18] develop a mobile apps named HuMAR (Human Anatomy in Mobile Augmented Reality). This apps is a reference to the topic of bones under the appendicular skeleton. The sample of this study was 30 students with an average age of 20 years from three universities. This study found that augmented reality-based learning could provide more understanding to students while increasing their motivation and effectiveness.

Augmented Reality Digestive System (ARDigestion) is a mobile apps develop in the study of Rizqi et al[19]. He mentioned that the human digestive system is one of the topics taught in Biology subjects in upper secondary schools in Indonesia. This study also concluded that Augmented Reality could be applied as a medium for learning the human digestive system. [20]study developed an Augmentation-based mobile apps by using a textbook as a marker for the topic of cell structure and

organisation for Form 4 secondary school students taking Biology subjects. The findings of this study showed that the usability aspect received the most positive feedback with a mean value of 4.12. Descriptions of some of the past studies above are summarised in Table 1 below.

Table 1:

Past studies of Augmented Reality-based mobile apps construction in Biology

No.	Researcher	Year	AR apps Name	Target students	Biology topics	Findings
1	Siti Salmi et al.	2015	HuMAR	University students (20 years old)	the bones below the appendicular skeleton	AR could give more understanding to students while increasing their motivation and effectiveness.
2	Ng et al.	2016	ATTech System	Form 4 (16 years old)	mitosis, meiosis and respiration	AR could enhance the effectiveness and appeal of the students' learning environment.
3	Rizqi et al.	2017	ARPencernaan	Upper secondary school	human digestive system	AR could improve student achievement and is very suitable to be applied as a medium for learning the human digestive system.
4	Lim	2019	Aplikasi Buku AR Interaktif	Form 4 (16 years old)	cell structure and organisation	The usability aspect received the most positive feedback

Based on the findings of previous studies in Table 1, it confirms that AR has great potential to be a catalyst for a new approach in the teaching and learning of Biology subjects. According to [21], AR promotes that mobile AR learning tools in inquiry-based learning activities are highly effective, adds motivation, and is simple compared to conventional inquiry-based learning approaches. According to[22], cell Biology teaching is often considered difficult, both by students and teachers. The hindrance of creating mental models by students and the lack of resources used by teachers in didactic transposition make the teaching and learning process difficult. [23] reported that many students struggled understanding microscopic structures, mainly because they could not see or manipulate them. Students experience many obstacles in remembering the names of structures and functions[24].

METHODOLOGY

Research design

The research design of this ARcell mobile apps study used development research [25, 26]. [3]maintained that an approach to be included in the title of a development study must have more of a balance between development and research. This ARcell mobile apps development used the ADDIE model. ADDIE is an acronym for Analyze, Design, Develop, Implement, and Evaluate that referring to it five phases.

Respondent

Respondents involved in this study consisted of three categories: expert respondents to assess the content and technical validity of the ARcell mobile apps and two groups of Form 6 students aged between 18 to 20 years to assess the reliability and the usability of the apps. Five experts were selected through purposive sampling according to their respective expertise. At the same time, student respondents were selected at simple random by using [27] Table. The demographic information of the study respondents according to the assessment and phase of involvement is shown in Table 2 below.

Table 2:

Demographic information of study respondents according to assessment and phase of involvement

No.	Assessment	Engagement phase	Respondent	Number
1	Content and technical validity of the apps	Implementation	expert	5
2	Apps reliability	Implementation	student	35
3	Apps usability	Evaluation	student	101

Instrument

This study employed three instruments: ARcell mobile apps content and technical validity questionnaire, ARcell mobile apps reliability questionnaire, and ARcell mobile apps usability questionnaire.

The ARcell mobile apps content and technical validity questionnaire [28] adapted study and was conducted based on the consent
of five experts with experience in their respective fields. ARcell mobile app improvements were made based on their suggestions and views. Researchers used a four-point Likert scale, namely 1 = strongly disagree, 2 = disagree, 3 = agree and 4 = strongly agree. The distribution of items in the content and technical validity questionnaire are shown in Table 3.

Table 3:

Distribution of items in the content and technical validity questionnaire

Content validity questionnaire

No.	Components	Number of items
1	Content Design	10
2	Mobile Apps Activity Organisation	10
	Number of items	20
	Technical validity questionnaire	
No.	Components	Number of items
1	Presentation Design	12
2	Interactivity Design	12
3	Constructivism Learning Theory	10
4	Mayer's Multimedia Learning Theory	12
	Number of items	46

The apps reliability questionnaire composed by the researcher was based on the objective of ARcell mobile apps formation, which refers to the learning outcomes in the Form Biology syllabus as recommended in the book of [8]. This questionnaire was distributed to 35 Form 6 students who took Biology from five schools in Malacca. Experts validated the questionnaire, and Cronbach's alpha reliability value was 0.91. The questionnaire used a five-point Likert scale with 21 items from three subtopics, as shown in Table 4.

Table 4:

Distribution of items by subtopic

No.	Components	Number of items
1	Prokaryotic and Eukaryotic Cells	5
2	Cell components	5
3	Specialised cells	11
	Number of items	21

The ARcell mobile apps usability questionnaire was adapted from the Post-Study System Usability Questionnaire (PSSUQ) [29]. It was distributed to 101 Form 6 students who took Biology from three schools in Malacca. Experts validated the questionnaire, and Cronbach's alpha reliability value was 0.94. This questionnaire used a five-point Likert scale with 21 items from seven aspects, as shown in Table 5.

Table 5:

Distribution of items according to aspects

No.	Components	Number of items
1	Design/ Layout	3
2	Functionality	3
3	Usability	4
4	Learnability	3
5	Satisfaction	3
6	Future Results/Uses	3
7	System Error/Reliability	2
	Number of items	21

Study Procedures

The first objective of this study was to develop an ARcell mobile apps to be used for the title Structure of Cells and Organelles of the subject of Biology Form 6. The development procedure of this apps was based on the ADDIE model that consist of five phases. The first phase of the ADDIE model was the analysis phase which is the basis for the subsequent phases. In the Analysis phase the researcher should identify the probable causes for a performance gap. The
concept of Design phase is to verify the desired performances and appropriate testing methods. Next, the Develop phase concept is to generate and validate the learning resources. In the Implement phase, researcher have to prepare the learning environment and engage the students At the last phase which is the Evaluation phase, the researcher have to assess the quality of the instructional products and processes, both before and after implementation.

The Analysis phase was the phase that solves and identifies the problem as a whole. Several analyses need to be done at this phase, such as user analysis, learning environment analysis, and determination of teaching goals and objectivesA Needs Analysis questionnaire was conducted in the analysis phase using Google Form to Biology teachers teaching at various levels (Forms 4, 5, 6 and matriculation), including gender, Biology teaching level, state, and duration of teaching experience. In addition, information such as the level of ICT skills, the type of mobile device owned, the level of capability of the mobile device, how to connect to the internet, and the choice of title suggestions that are appropriate for the ARcell apps were asked. The findings from 41 biology teachers who were respondents indicated the highest percentage of 84.9%, which comprised teachers who teach Form 6 and matriculation, with 67.5% of respondents with more than ten years of teaching experience. Respondents also had the level of ICT skills at the proficient (42.5%) and moderately proficient (55%) with the percentage of owning a smartphone of 90%and using wifi (90%) for internet access. The proposed title that had the highest percentage of 48.7% was from the topic of the second chapter, which is the Structure of Cells and Organelles, which covers 14 periods according to the Form 6 Syllabus of Biology.

The next phase was the design phase, where the production of Flowcharts, Interfaces and Storyboards in designing AR mobile appss occurred, and it was imperative. Mayer's Multimedia Cognitive learning theory (2001) and Constructivism Learning Theory were also adapted. The features of the ARcell mobile apps in terms of technical and multimedia were based on the guidelines of Mayer's Multimedia Cognitive Learning Theory (2001), while the learning activities of the ARcell mobile apps were based on the elements contained in Constructivism Learning Theory. Each of the built-in marker cards had the same Level sequence, i.e. L1, L2 and L3. While the smartphone camera scanned the marker card, students would see 3 Dimensional (3D) images with interactive labels on L1. At the L2 level, students would go to the next display to see features and other note information, and then students would be given questions objective interactive reinforcement questions at the L3 level. Figure 1 below shows actual pictures of Level 1, Level 2 and Level 3. The third phase was developing ARcell apps, following the analysis phase and design phase. According to[30] [31]in the development phase of screen design aspects consisting of several multimedia principles such as text principles, graphics (2D/ 3D objects), audio, video animation and colour should be met. In this phase, researchers need to provide more specific and quality teaching materials and need to arrange course materials step by step in sequence[32]. Researchers also combined 2D pictures from Form 6 reference books and pictures from internet sources and modified all the pictures to form 3D virtual images that follow the student learning syllabus.

The features found in the ARcell mobile apps based on AR technology was that it had multiple 3D and 2D virtual images, had interactive features on labels, objective

quizzes, the use of human voice narration, complete with concise and precise notes, had a video link to youtube, essay questions in the

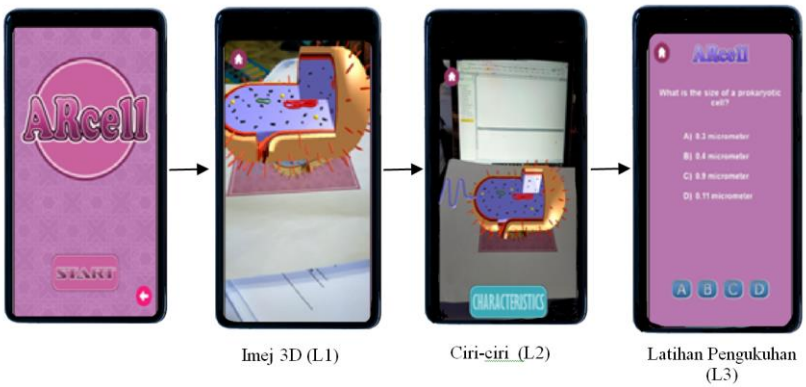

Figure 1: Levels on each marker card (L1, L2 and L3)

form of HOTS (Higher-Order Thinking Skill). It required minimal internet data and was only required once, that was, during the first download. Once the apps was successfully downloaded, students could use it repeatedly in self-learning without a time limit. It is beneficial for the teaching and learning of students, especially at a time of the COVID-19 pandemic, in which the distribution of textbooks or the purchase of reference books is complex due to the Movement Control Order (MCO). The use of the complete ARcell mobile apps included one chapter and its features that could be easily downloaded directly in various ways (Bluetooth, Share it, Telegram), greatly aiding the teaching and self-learning of students at home.

The next phase was the implementation phase. According to [33]every problem identified in this phase will be fixed and redeveloped until the objectives of the apps are achieved to ensure that the apps can be appropriately used before testing on users is done. A general implementation strategy is planning for students and teachers as facilitators [26].

This implementation phase began with the validation process of the ARcell mobile apps. The researcher conducted initial discussions with the supervisor to determine the experts who would evaluate the validity of the content and the technical validity of the ARcell mobile apps. The evaluation of the validity of the ARcell mobile apps by experts was made using two questionnaires: the ARcell Mobile Apps Content Validity Questionnaire and the ARcell Mobile Apps Technical Validity Questionnaire. A total of 5 experts with experience and expertise in the content and technical aspects were selected and contacted by phone and email.

After obtaining their consent, the researcher contacted the Postgraduate Institute (IPS) to obtain a letter of appointment of an expert. Expert appointment letters, ARcell Mobile Apps Content Questionnaire, ARcell Mobile Apps Technical Validity Questionnaire, ARcell Mobile Apps and ARcell mobile apps usage manual were communicated to the experts via email. Experts were given information on how to use the ARcell apps also via email and Whatsapps. It was due to the MCO, which was taking place at the time. All experts took about a month on average to evaluate the validity of this ARcell mobile apps. All aspects of suggestions and improvements from experts were considered and considered to improve this ARcell mobile apps.

During this implementation phase, the researcher also conducted an assessment of the reliability of the apps. The ARcell Mobile Apps Reliability Assessment from students' perspective was targeted at 36 Form 6 students who took Biology subjects from five schools in Malacca. The researchers briefed and explained the use of the ARcell mobile apps and its implementation procedures before the teaching and learning sessions began. Teachers conducted self-exploration based on the teacher's manual and the ARcell mobile apps Handbook provided by the researchers. With the

help of teachers, students took turns exploring the ARcell mobile apps using smartphones and tabs provided by the researchers. Group use could not be carried out as the school had to follow the SOP (Standard of Procedure) set following the COVID-19 pandemic that hit the whole country. Precautions were also considered by the researchers, whereby before the use of the devices, both hands of the students were sprayed with hand sanitiser. The smartphones and tabs used for this study were also sanitised each time before their use in a school.

The evaluation phase was the last phase in the ADDIE model where it involved formative evaluation and summative evaluation. Formative evaluation is an ongoing evaluation throughout the ARcell mobile apps formation process. Researchers made continuous improvements based on the recommendations of supervisors and the views and recommendations of experts. The summative evaluation in this study was based on the usability of the ARcell mobile apps from the perceptions of 101 Form 6 students who took the subject of Biology. Students' assessment of the Usability of ARcell mobile appss covered seven aspects: Design/ Layout, Functionality, Usability, Learnability, Satisfaction, Results/ Future Use, and system errors/ reliability

RESULTS AND DISCUSSION

Content validity and technical ARcell mobile apps

The second objective of this research is to determine the content and technical validity of ARcell mobile apps, The validity of the ARcell mobile apps by the expert referred to two assessments, namely the ARcell Mobile Apps Content Assessment and the ARcell Mobile Apps Technical Assessment. For ARcell Mobile Apps Content Evaluation, all experts strongly agreed with the content evaluation aspects, which referred to Content Design and Organisational Design of ARcell mobile apps activities with the highest S-CVI value of 1.00 (Table 6).

Table 6:

Overall S-CVI values

No.	Aspect	S-CVI
1	Content Design	1.00
2	Activity Organisation Design	1.00
	S-CVI Overall	1.00

Meanwhile, the overall value for the technical validity assessment of ARcell mobile apps, which referred to the aspects of Presentation Design, Interactivity Design, Constructivism Learning Theory and Mayer Multimedia Cognitive Learning Theory, was high at 0.97 (Table 7). It confirmed that all experts agreed with the technical aspects found in this ARcell mobile apps.

Table 7:

Technical evaluation by experts according to the aspects along with the value of S-CVI

No.	Aspect	S-CVI
1	Presentation Design	0.95
2	Interactivity Design	0.97
3	Constructivism Learning Theory	1.00
4	Mayer's Multimedia Cognitive Learning Theory	0.97
	S-CVI Overall	0.97

According to [16], an I-CVI scale of 0.78 or higher and an S-CVI / Ave of 0.90 or higher had excellent content validity. This high and excellent value resulted from a potent combination of concepts and development, good items, excellent experts, and clear instructions on constructs and evaluation tasks. Overall, the validity of the ARcell mobile apps developed by the researcher had high and perfect validity for I-CVI and S-CVI values for both evaluations, namely ARcell Mobile Apps Content Evaluation and ARcell Mobile Apps Technical Evaluation. According to Ghazali & Sufean [29], the higher the instrument's value and level of validity, the more accurate the data obtained to produce a good and high-quality study.

Among the aspects favored by the experts is this ARcell Mobile Apps featuring interactive virtual images 3D shapes as well as informative notes containing sections that test the student comprehension. According to the experts, the ARcell Mobile Apps is an exciting application based on the use of the latest mobile phone technology.The ARcell Mobile Apps can also provide visual impact to students through 3D virtual images based on Augmentation Reality to enable an efficient learning experience to take place and in turn it can provide an understanding of the topic. Further study of [15] also showed that AR provides a greater ability to visualize hidden details and information and can help students learn science. Through its 3D visualization and interaction, the AR system facilitates the explanation and conceptualization of abstract concepts that cannot be easily described. with traditional pedagogical strategies [5].

The findings of [34]study, also showed that their students gave the highest agreement that AR greatly contributed in concreting abstract concepts and factual information in biology. Hence, it proved that this mobile apps is very relevant and effective in teaching and learning aid for students and had great potential as a catalyst to a new approach to today's global learning based on Augmented Reality.

Reliability of ARcell mobile appss

The third objective of this research is to determine the reliability of ARcell mobile apps. A pilot study is conducted on a small scale before the field study is implemented to ensure that the module content can be used during the field study [35, 36]. Researchers analysed the study's findings to obtain Cronbach's alpha values for the reliability values of this ARcell mobile apps.

The ARcell Mobile Apps Reliability Assessment from students' perspective was targeted at 36 Form 6 students who took Biology subjects from five schools in Malacca. Based on the Reliability Level Interpretation Table through Cronbach's alpha value [37], the overall value of Cronbach's alpha for ARcell mobile apps Reliability assessment was at an excellent level of 0.94. Table 8 shows the Cronbach's alpha values obtained from the students 'perspective for the ARcell Mobile Apps Reliability Assessment.

The apps reliability questionnaire constructed by the researchers was based on the objectives of ARcell mobile apps construction, which referred to the learning outcomes. These findings showed that this ARcell mobile apps received high-reliability status among students. Values close to 1.00 indicated that the items have high reliability, and the error on the measurement is small [38].

The developed ARcell mobile apps was fully compliant with the curriculum and learning outcomes of Biology Form 6 Semester 1 and gained a high level of trust among students. Therefore, at the time of the COVID-19 pandemic that hit the country and the world, this ARcell mobile apps is very relevant to aid in teaching and learning from home (PdPr). Teachers can also be facilitators, and students can do self-learning repeatedly to achieve the set learning outcomes. It supports the conceptual framework of Form 6, which refers to "self-learning" with teacher guidance in teaching and learning

Table 8

Assessment of ARcell mobile apps reliability from a student perspective

No.	Construct	Number of Items	Cronbach's alpha value	Overall Cronbach's alpha value
1	Prokaryotic and Eukaryotic Cells	5	0.81	0.94
2	Cell components	5	0.73	
3	Specialised cells	11	0.95	

The usability level of the ARcell mobile apps

The fourth objective of this research is to evaluate the level of Usability of ARcell mobile apps from students' perceptions. The determination of the usability level of the ARcell mobile apps was implemented to a total of 101 Form 6 students who took Biology subjects from three schools in Malacca. The level of usability of the ARcell mobile apps in this study was using [39] Mean Score Interpretation which refers to the mean value and standard deviation. Students' assessment of the usability of the ARcell mobile apps covered seven aspects: Design/ Layout, Functionality, Usability, Learnability, Satisfaction, Future Results/ Usage, and system error/ reliability. Based on Table 9, the highest overall mean score value of 4.10 was for the aspect of usability, followed by the aspect of learnability which was 4.05, the aspect of satisfaction (4.01), the aspect of functionality (3.90), the aspect of design/ layout (3.89), the aspect of future results/ use (3.82) and the lowest was the error/reliability aspect of the system which was 3.67. Overall, all aspects/constructs were at a high level of more than 3.67, with the average overall mean was at a high level of 3.94 (SP = 0.68) [39]

Table 9

Student evaluation of the Usability Level of ARcell mobile apps (mean value and standard deviation by aspect/ construct)

No.	Aspect	Mean score	Interpretation of Mean	Standard deviation
a)	Design/ Layout	3.89	Very good	0.67
b)	Functionality	3.90	Very good	0.68
c)	Usability	4.10	Very good	0.68
d)	Learnability	4.05	Very good	0.61
e)	Satisfaction	4.01	Very good	0.70
f)	Future Revenue/ Use	3.82	Very good	0.68
g)	System Error/ Reliability	3.67	Very good	0.77
	Overall	3.94	Very good	0.68

The overall level of student agreement for the aspect of design or layout was high at 3.89. This showed that the students strongly agreed with this mobile apps's design or layout, which had a clear information organisation, pleasant interface arrangement, and preferred. The overall mean level value for this aspect of functionality was also at a high level of 3.90. The study of [18] meanwhile showed the ability to change the viewing angle of 3D objects spurred their interest and desire to learn, and textual information (labels) provided to enhance their memory where they stored the collected

information longer. The ARcell Mobile apps also allows students to make explorations similar to the study of [18] where students are free to make viewing angle changes, resize 3D objects and even create activities on labels and interactive objective quiz questions. The results of their study also found that the value of the overall mean level for this aspect of Functionality is also at a high level of 3.90. This showed that this ARcell mobile apps had an exemplary aspect of functionality for use in teaching and learning. The items in this aspect/construct had a high mean value where students agreed that this ARcell mobile apps contained all the functions and capabilities expected and had features that work well while providing precise information.

The next aspect was usability, which had the highest overall mean value compared to other aspects, which were 4.10. Students also found this ARcell mobile app overall easy to use and easy to find information. The mean value for the aspect of learnability as a whole was at a high level of 4.05. The students agreed that the information provided in this ARcell mobile apps was easy to understand, and its use made it easy for them to learn without needing much other information to use it properly. The AR-based study [5] also showed that the aspects of learnability tested on students got excellent acceptance.

As for the aspect/construct of satisfaction, the overall mean value of this aspect was also at a high level of 4.01. The item “I felt comfortable using this ARcell mobile app” recorded the highest mean value compared to other items, which was 4.06. In addition, the students also agreed on other items referring to the comfort of using this app and feeling satisfied with this app as a whole. This finding was supported by [40], who also studied the aspect of user satisfaction of AR-based apps, and they found that respondents strongly agreed that AR technology is desirable for students.

The next aspect was Future Results/ Usage, which recorded a high overall level of agreement of 3.82. Students agreed that the use of this ARcell mobile apps had succeeded in convincing them to improve their skills and knowledge and quickly become productive and will use it more often in the future. The last aspect was the Error or System Reliability aspect, which recorded a high overall agreement level of 3.67, where the students strongly agreed that when they made a mistake while using this apps, they could correct it easily and quickly.

Overall, this study showed that the level of student agreement on evaluating the usability of ARcell mobile appss was at a high level, with an overall mean value of 3.94. It showed that the students gave positive feedback on the usability of this ARcell mobile apps in terms of all seven aspects, namely design or layout, functionality, usability, learnability, satisfaction, future results/ use and system error/ reliability. Therefore, this ARcell Mobile Apps is beneficial and very useful as an alternative aid in teaching and learning based on Augmented Reality (AR). The findings of this study are also parallel and supported by findings from previous studies based on other mobile AR apps. This ARcell Mobile Apps is very relevant and practical particularly in applying student self-learning during the country as well as the rest of the world facing the Covid-19 pandemic situation. The findings of of Umar et al. [48] also found that biology learning activities through AR-based media can support learning during the Covid-19 pandemic

CONCLUSION

Researchers developed the ARcell mobile apps using the ADDIE instructional design model. The results of the study showed that this module obtained the value of content validity coefficient (I-CVI = 1.00) and the value of technical validity coefficient (I-CVI = 0.97) and a high-reliability value (α = 0.94). For the usability level of this ARcell mobile apps, the mean value for each of the seven aspects/constructs was design/layout (3.89), functionality (3.90), usability (4.10), learnability (4.05), satisfaction (4.01), outcome/usage future (3.82), system error/ reliability (3.67). Overall, the results of the evaluation of ARcell mobile apps in terms of content validity and technical experts, apps reliability and apps usability, it could be concluded that

ARcell mobile apps had great potential to be used as the primary support in teaching aid for teachers and self-learning for Form 6 students for the topic of Cell Structure and Organelles in the subject of Biology.

Ergo, this ARcell mobile apps is pertinent in promoting self-learning to students, especially during the COVID-19 pandemic situation where the teaching and learning of this apps can be carried out in all three situations, namely online, offline and offside by teachers and students, in their respective homes. Therefore, this ARcell mobile apps is convenient and has a high potential to be a pioneer and catalyst for a fresh teaching and learning approach based on Augmented Reality, coinciding with the notion of Education 4.0 in the epoch of Industrial Revolution 4.0 (4.0 IR) for realising the goals of the Malaysia Education Development Plan 2013-2025 (PPPM 2013-2025)[1]

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