Assessing Usability of Learning Experience Prototype

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Abstract—The boost of mobile devices and internet technologies has led to the development of new content geared to enhance the learning experience of students while simultaneously ensuring the economizing of the teacher's time. The era of industrial revolution 4.0 transformed many aspects of life including the basic approaches towards teaching and learning. The needs and demands of students and teachers are changing in line with the revolution of emerging technologies. However, even with the advent of technology, STEM subjects are yet to fully grasp the attention of students. Learning especially in secondary schools and higher education intuitions needs to be redesigned to improve students' learning experience, especially in STEM subjects which involve complex concepts and processes that are difficult to visualize and require students to be fully engaged. Accordingly, this paper discusses the design and development of a learning experience model aimed at improving the teaching of Biology subjects. The model emphasized on three factors; content, pedagogy and interaction. Multimedia elements such as 2D graphic, video, AR with 3D object and gamification concepts were included in the design. A prototype called m-BioP was developed based on the designed model and heuristic evaluation was performed to ensure the application's usability. It was verified by six experts and it is identified that 19/24 (79%) items are well designed and some changes (8/24 items) require improvement. Future studies need to be conducted to approved the designed model.

Keywords—biology animal development, interactivity, m-learning, 3D objects, emerging technologies, visualization, heuristic evaluation

1 Introduction

Traditional teaching and learning (T&L) is limited to specific locations such as classrooms and laboratories where teachers moderate the T&L process from beginning to the end, with students required to be physically present to participate in the T&L activ-

ities. Past research has examined traditional T&L methods and found latent dysfunctions [1 - 3] such as limited stimulation to students' interest and motivation. With studies having proven that young people are more inclined to digital and online content and they are able to earn higher marks through online learning [2] with promising signs especially for technical subjects such as Science, Technology, Engineering and Mathematics (STEM). Therefore, educators have to take the opportunity of the technological capabilities to develop digital content that suit students need in order to motivate and engage students.

The learning experience in the classrooms are undergoing major changes due to emerging technological trends in education [4]. The demand for experiential learning drives learning outcomes with emerging technologies including gamification, 3D Objects, Augmented Reality (AR) and video. Learning becomes more interactive than traditional approaches as students need to be proactive in navigating various features in learning apps. For example, feature of AR with 3D objects provide more immersive material that students able to interact by zooming and rotating the image from various angles [5]. The use of emerging technologies can explain complex concepts that cannot be explained to students through normal diagrams.

The design of the learning experience should not only focus on students but also emphasize on the delivery of content according to the current learning ecosystem. Failure in T&L should not be blamed solely on individual weaknesses but it may be due to poor learning experience design. According to [6], there are three main factors to consider in designing a learning experience; (i) reduce additional cognitive load, (ii) create content that supports all types of students, and (iii) develop a supportive learning environment. The design of student learning experiences should consider subject, pedagogy, user experience and interaction [7].

In line with the Fourth Industrial Revolution (4IR) driving the emergence of today's learning scenarios, many technological approaches are applied in learning. Among them are virtual learning approaches using specific devices, with 2D and 3D graphics, gamification concepts, and AR. There are studies that combined several elements subject to compatibility with the topic and the learning style of the students. However, most learning materials overemphasize one element such as games or AR only. For example, a research conducted by [8] produced a prototype of learning gamification. Although it focused on gamification, prototype evaluation resulted an increase in motivation and interest in programming. A study by [9] that combined gamification and storytelling elements in AR applications delivered positive effects on student performance. This suggests that more diversity of elements combined can produce better results in the T&L process.

This study aims to design and develop a model of learning experience that may be able to enhance students' learning experience that was validated through a mobile learning prototype which was further evaluated by appointed experts. Animal Developmental Biology was chosen as the subject content because it contains complex information that can be visualized in various forms such as in 2D and 3D graphics and video. The objective is for students to have better learning experience by highlighting the unique processes of animal development from gametogenesis to the stage of animal develop-

ment that occurs either inside or outside the female reproductive system. The integration of gamification, 2D graphics, video and AR elements may be able to enhance the learning experience by better attracting and retaining students' interest in the subject. Prototypes included learning modules that utilized AR technology, video and infographics while reinforcement activities such as training and assessment through gamification technology with reward points, scoreboards, timers and dashboards were incorporated as suggested by [10].

This paper discusses previous studies of similar work in Section 2.0. Section 3 discuss the use of methodologies for designing, developing and validating models. Section 4.0 discusses the evaluation results and the updated model. The last section summarizes the results of the study and the limitations of the research as well as implications for future work.

2 Related works

M-learning or mobile learning is now a feature in life as this approach provides borderless access for learning as opposed to face-to-face methods. Learning can take place without immense physical infrastructure, providing opportunities for those who are unable to be physically present in a specific area and time. With the convenience of mobile devices, information can be accessed anywhere and at any time. Moreover, high speed internet help m-learning applications work wonders via mobile devices. According to a government survey in 2020, internet users spend more time online as compared in 2018 [11]. Thus, proving that the application of m-learning significantly concurs with the objective in improving the quality of T&L.

One of the factors to improve T&L quality is by encourage active participation of students in learning activities. In traditional classes, students who are active in the learning activities normally show excellent performance in terms of learning attitude as well as the score [2], while being unconducive to students with introvert character and low self-esteem who are urged and motivated to actively participate under incompatible T&L methods. This type of students can regularly compensate for their lack of face-to-face interaction with online interaction [12]. Therefore, the design of m-learning applications must incorporate interactivity features as such features adequately compensate for the lack of face-to-face interaction among inactive students. In m-learning, interactivity can be in a form of freedom of letting students decide what to do or via user control which opposes the method applied in traditional classroom in which the decision is made by the teacher. It is also necessary to offer a variety of learning activities such as watching videos, browsing notes, viewing 2D and 3D graphics or even playing games as part of interaction and pedagogy media. The students can start, break and continue their learning at their convenience. Furthermore, most applications can keep track users' activities; successfully mirroring teachers' monitoring in traditional class.

Gamification concepts that are frequently applied to current applications can be seen as one of emerging technologies. Applications for learning, shopping, entertainment, bill payment apps have been designed and developed for their specific purposes using game elements implanted in the design. For example, points will be awarded to the

students if they able to accomplish certain activities, which replicates in-game reward systems. Some learning applications use rank to categorize users based on their activities and assessments' marks. These are the concept of gamification (rewards, rank, etc.) that were applied in non-game applications which are believed to increase students' engagement and loyalty [8]. Despite that, AR technology is also considered as a factor to increase the engagement. It is proven that AR feature in learning able to improve student understanding by visualizing complex or spatial structures [13]. The goal is to presents class material and assessments in a more interactive, engaging and convenient way directly to improve quality of T&L.

Research done by [7] reported that learning application should consider good design of pedagogy and interaction to design specific content to enhance student learning experience. Students exhibit better performance when they enjoy their learning. [14] and [15] emphasize on gamification to enhances learning experience and concluded that their design contributed to student-centered learning. In a similar study, [16] identified that students' learning experience improved and as proven by improved academic results as they achieved better scores in practical assignment and overall score. [16] also focused on embedding gamification in the T&L application.

2.1 Learning experience model

There are many studies investigating on the factors that influence learning experience. Those factors are evaluated based on various grounds and approaches, even so the main intention is remaining the same; to enhance student learning experience. Student learning experience refers to knowledge and skill that an individual gained in learning activities that can be assessed through tests, interviews, survey and observations. The aim of this study is not only assessment but on identifying key factors in designing a model of learning experience. [17] emphasized multiple factors including interaction: it was discovered that technology plays a big role in producing active interaction between peers and teachers. This interaction is associated to building reliable social relationships that enhance the learning experience. [18] conducted a similar study that further discussed two factors: interaction and technology simultaneously focusing on designing a conceptual model of interactive learning experience. The evaluation of their model proved that interactive factor fosters good relationships between users and the product (application) factors that lead to meaningful learning experience. Methods used to deliver the content and the aesthetical standard is highly significant in ensuring the approval from students.

The emerging technologies like AR, gamification concept, expressive video and 2D as well as 3D graphics are some of the approaches to deliver the e-content. [13] proved that AR technology engage the students to the designed application as they presented notes and assessment interactively. [19] stated that even some students have difficulties in using AR technology, but highlighted the main advantage of learning gain which directly related to learning experience. [20] concluded in their synthesis research study that AR has a moderate impact on learning gains and the success of AR was also influenced by other pedagogical approaches and environmental factors. For instance, [18] incorporated reward elements into gamification concepts when designing the model of

learning experience. They determined that gamification concepts should be included in education products (applications) designed for youngsters. The comparison study done by [14] showed a significantly higher performance of students who participated in the application with gamification concept compared to those who engaged with normal learning concept.

Aesthetic design of video and graphics in form of 2D and 3D able to retain students' attention and divert the tediousness of dull lengthy text into audio and visual materials to look at and understand. The transition from text to graphics and video is not an easy task but the visualization proved to be very much appreciated by the students. These approaches were frequently utilized and recognized by many research studies [14, 18, 20-21].

3 Methodology

The study applied Agile development methodology due to its flexibility and adaptivity towards technological changes. In mobile software engineering, this method is regularly used because application requirements are constantly changing and evolving according to user needs [21]. The processes involved in the development are 1) requirements analysis, 2) design, 3) development and 4) testing. A heuristic checking instrument was developed to test the usability of the application. Table 1 shows the detail approach of this study.

Table 1. Methodology

Agile Phase	Approach	Output
Requirement analysis	Interview Panel: Biology teachers and lecturers in the field of animal development	Scope of the study Problems Specifications of user needs
Design	Conceptualization Design conceptual model based on literature review	Model of learning experience
Development	Develop prototype (based on model) Interfaces and interactions Content Programming and database	m-BioP
Testing	Heuristic Evaluation Panel: Experts in application and game design	Verified Model

3.1 Document content

The interview session with Biology teachers and lecturers (panel) was conducted in Malay language and attended by one expert and one interviewer per session. The experts were selected based on their experience in teaching Biology. Three experts were appointed for the requirement analysis as stated by [23] mandating small sample size of experts that involve more contact time are enough to identify problem and basic requirements. The interviewer explained the purpose of the study followed by questions related to STEM subject issues. Table 2 shows the list of question that is adapted from

[24] and the following guidelines of interview study by [25] and [26]. Since the interview was conducted in Malay language, the questions are translated accordingly.

Table 2. Methodology

Num	Question
1	Do you think current method/ tool is helpful in teaching and learning?
2	Do you think student are able to learn topics has to be taught? How do you know?
3	What are the topics that students find difficult?
4	How do student learn and how can they learn better?
5	How can a teacher/ lecturer contribute to students learning?
6	What affects teaching and learning?

3.2 Conceptualization

Conceptualization method aims to integrate important elements that influence learning experience based on similar studies. This method synthesized outcomes of past research that may suitable for the scope of the study. Several studies applied the method to create their research models or frameworks [7-8, 27]. Figure 1 shows the suggested learning experience model generated through the conceptualization method.

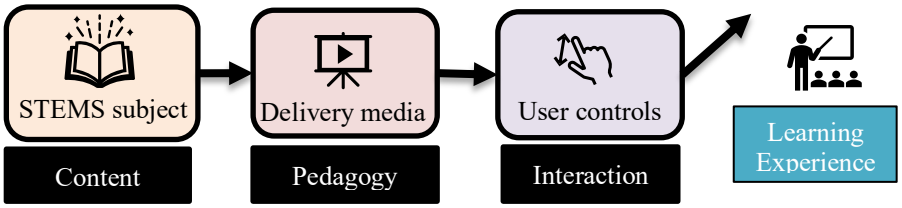

Fig. 1. Suggested learning experience conceptual model

3.3 Prototype development

The prototype called m-BioP was developed using multiple software including unity, visual studio, phpMyAdmin, vuforia, Figma, Canva, blender and Adobe XD. This software was used for creating multimedia including 3D and 2D objects, database, algorithm and coding. The development of m-BioP was based on the learning experience model and spanned about 15 weeks with 4 cycles of meeting with designers, programmers and research's team.

3.4 Heuristic evaluation method

There are numbers of evaluation methods developed by usability researchers to measure usability problems. Heuristic evaluations are one of the most effective and frequently used methods in the field of human computer interaction [28]. Heuristic evaluation aims to identify usability problems related to the design of user interfaces

through experts' judgements. Usability refers to the quality of a user's experience when they interact with the interface of a product such as a website, software, device or application. Experts are given an instrument as a guideline to evaluate the design of user interfaces. The selection of experts is one of the important factors to ensure the legitimacy of usability problems discovered. Another factor that must be considered in heuristic evaluation is the reliability of the instrument itself. Heuristics instruments built by [28] called Nielsen's 10 heuristic principles have gone through a content validation process that are frequently applied in the studies of [29 -31]. However, some argue that the heuristics generated by Nielsen are too general to properly identify specific usability problems [32]. Moreover, it is argued that evaluation criteria or sub-heuristics should be generated based on the study domain. Therefore, in accordance the purpose of the study, heuristic instrument was adapted from [28] and some items are added to the instrument. Then, instrument validation was conducted in a group involving three experts in the field of e-learning, multimedia, and gaming. Although the instrument has been validated in the past studies, this process is to ensure that the instrument is easily understood and able to measure the research's aim. The descriptions of ten heuristic criteria were explained in heuristic form and each principle has one to five sub-heuristics. Finally, the instrument can be used for measuring the user interface design of m-BioP. The total of heuristics are 28 items in Malay Language as shown in Appendix.

Six experts with prior experience in application's evaluation were appointed to evaluate the applicability of M-BioP. At the beginning of the evaluation study, seven experts were invited to evaluate M-BioP. Six of the experts agreed within the allotted time. An expert declined the invitation due to time constraints. A minimum of five experts was sufficient to obtain usability problems for a developed application [28]. These six appointed experts are regularly involved in designing and developing new applications. Therefore, the main criteria for the selection of experts required two specific expertise: 1) prior experience in evaluating the usability of applications and 2) Prior experience designed and developed learning applications. According to Nielsen multiple expertise criteria allow 85% of usability problems to be identified. Through this heuristic evaluation method, experts were invited to critique the M-BioP through the evaluation documents provided. The evaluation document contained 1) Usability heuristics 2) marker cards for augmented reality and 3) M-BioP application installer. Experts were required to install M-BioP to their respective android devices and are asked to explore M-BioP before making an assessment.

The evaluation was based on five main scales to measure the severity of the usability problems as shown in Table 3. Experts were also asked to provide suggestions for improvement for the usability problems found.

Table 3. Severity scale of usability problem

Scale	Usability Problem
0	Usability Problem not exist.
1	Cosmetic problem, no compulsary modification
2	Simple usability problem, low priority in modification
3	Main usability problem, high priority in modification.
4	Critical usability problem, modification is a must.

4 Result and discussion

This section discusses the result for the agile phases of the methodology as described in Table 1 and followed by a brief discussion of each result.

4.1 Requirement analysis and conceptualization

Each interview session for requirement analysis ranged from 40 minutes to 90 minutes. Based on the analysis of panels' responses, Animal Developmental Biology was identified as one of the topics that contain complex information requiring more time to deliver. All panels having difficulties showing detail figures due to limited accurate yet appealing material. Two of the interviewees highlighted inadequate interaction among students especially those of low self-esteem and introverted personalities. Similar findings were reported by [12] in which individuals with low self-esteem were uncomfortable interacting in a face-to-face context and compensated by using online interactions. One of the ways to have an effective T&L is by providing a learning platform that is able to encourage students to actively participate in the learning activities. Hence Animal Development Biology was selected as the main content of the prototype. Four sub-topics of Animal Development Biology were also identified based on panels' suggestions namely Reproduction, Animal development, Chicken development and Frog development. Table 4 shows the summary of findings from the requirement analysis phase while Figure 2 shows the updated learning experience model with detailed elements.

Table 4. Requirement analysis result

Scope	Animal Developmental Biology
Problem	Limited clear yet appealing material Inadequate interaction
Specification	Mobile, clear and interesting presentation of topic, encourage interaction, active participation

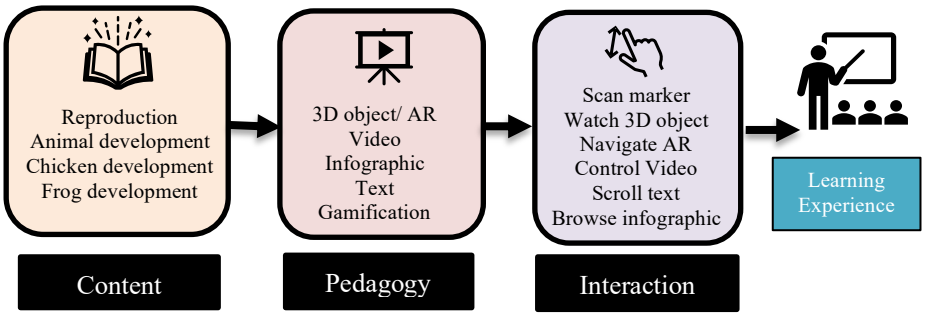

Fig. 2. Learning experience model

4.2 Prototype design and development

This section discusses the design of the application prototype. The prototype is called m-BioP and was designed as an Android compatible mobile application. Android operating system was chosen since 83.17% of mobile user population use android devices [33]. Animal Developmental Biology's notes were presented in the form of 2D or 3D objects through AR as well as video. The reinforcement of learning through gamification was employed especially on the assessments. Various user interactions were included to reduce the cognitive load of students and support various learning styles of students, further enhancing the user experience [34]. Figure 3 to Figure 6 shows the designs of m-BioP.

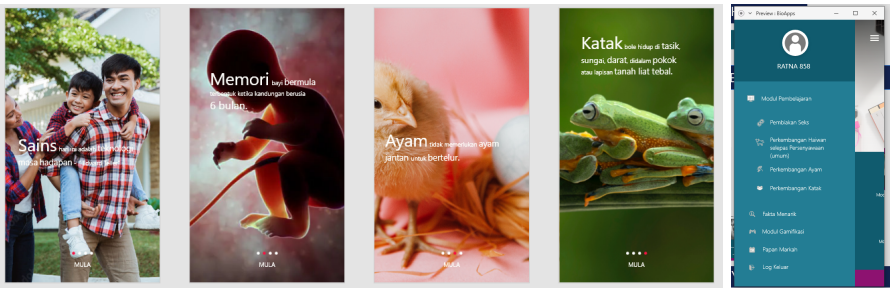

Fig. 3. Homepage (sliding)

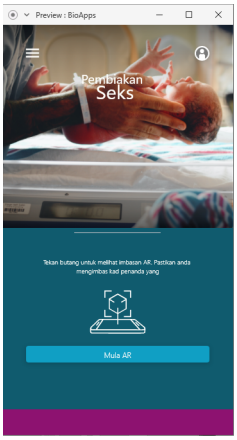

Fig. 4. Augmented reality page

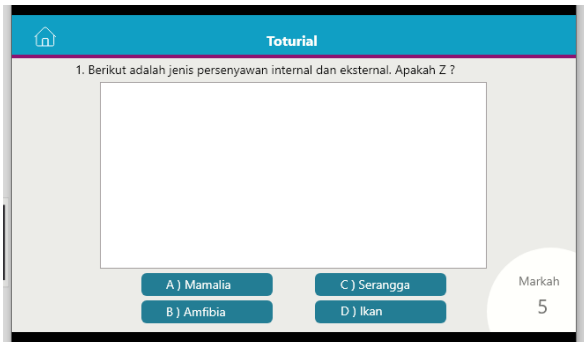

Fig. 5. Assessment page

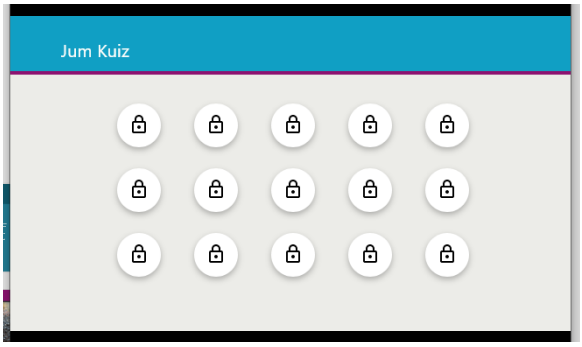

Fig. 6. Score board page

Users needed to log in using a registered name and password. The registration was necessary to keep track of users' records and progress. Once users logged in, they were able to the see list of topics and they were allowed to immediately answer questions in quizzes. Figure 3 shows the homepage of m-BioP. Since interactivity is one the main elements of the model, full user control of m-BioP was required. Thus, users could choose any learning activity to participate: watching video, viewing infographic, answering quizzes or browsing the 3D models through augmented reality feature. Figure 4 shows one of the example of augmented reality page in m-BioP while Figure 5 shows the assessment page that contains example of a quiz. Figure 6 shows the personal scoreboard button detailing the individual scores earned in each level. Students could also view their scores in each level on the dashboard. This dashboard is intended for players to identify weak points based on the number of points earned. Players can re-attempt these low scoring quizzes after reviewing the topic.

4.3 Heuristic evaluation result

The feedback received from the six appointed experts was analyzed by calculating the mean score for each item. Based on the mean scores, three action categories were

identified as shown in Table 5. For items with a mean score of less than 1.34, the interface design and features could be maintained, while items with a mean score between 1.34 to 2.67 could be improved and scores between 2.67 to 4.00 necessitates further improvement to avoid users facing critical usability issues.

Table 5. Improvement actions based on mean scores

Score	Action
0.00 - 1.33	Design is maintained
1.34 - 2.67	Design can be improved
2.67 - 4.00	Design must be improved

Analysis of mean scores and action categories on the 28 sub-heuristics displayed 19 items that were categorized as “Design maintained” and 9 items categorized as “Improved”. However, based on the mean score, no item was categorized as "must be improved". Table 6 shows the mean and action scores for all 28 sub-heuristics and Figure 6 shows the total number of sub-heuristics categorized into three Actions.

Table 6. Severity levels for sub-heuristics

Item	Score Mean	Action	Item	Score Mean	Action
1	0.83	Design is maintained	15	2.17	Design can be improved
2	0.83	Design is maintained	16	1.00	Design is maintained
3	0.33	Design is maintained	17	0.50	Design is maintained
4	1.33	Design can be improved	18	0.17	Design is maintained
5	1.17	Design is maintained	19	0.50	Design is maintained
6	1.33	Design can be improved	20	0.83	Design is maintained
7	0.50	Design is maintained	21	0.67	Design is maintained
8	2.00	Design can be improved	22	1.50	Design can be improved
9	0.17	Design is maintained	23	0.33	Design is maintained
10	1.33	Design can be improved	24	1.33	Design can be improved
11	0.50	Design is maintained	25	0.33	Design is maintained
12	0.67	Design is maintained	26	1.00	Design is maintained
13	0.33	Design is maintained	27	0.67	Design is maintained
14	1.33	Design can be improved	28	1.33	Design can be improved

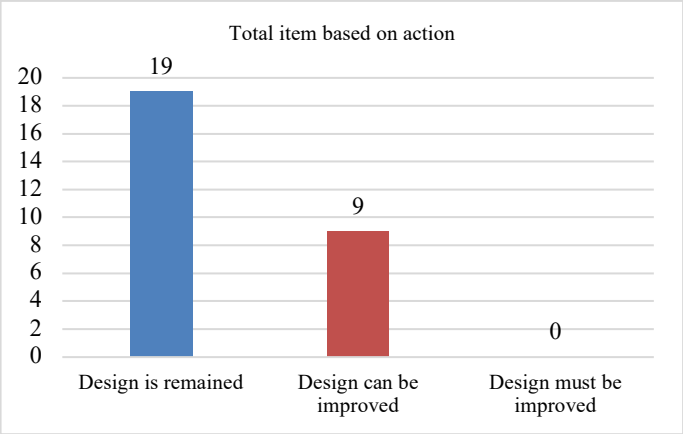

Fig. 7. Action categories based on mean scores for 28 items

The nine sub-heuristics categorized as "Improved" were the 4th, 6th, 8th, 10th, 14th, 15th, 22nd, 24th and 28th sub-heuristics. Table 7 shows the frequency of expert evaluation based on the severity level scale for the 9 sub-heuristics. The priority for improvement was given to sub-heuristics 8, 15 and 24 because over 50% of experts found critical usability problems on these three sub-heuristics. Based on expert comments, these three sub-heuristics referred to the video features (buttons on the video) and images found on the M-BioP.

Table 7. Frequency of expert evaluation for each scale

Sub-Heuristic	Severuty Level Scale				
	0	1	2	3	4
4	67%	0%	0%	0%	33%
6	17%	50%	17%	17%	0%
8	17%	17%	33%	17%	17%
10	33%	33%	0%	33%	0%
14	33%	33%	0%	33%	0%
15	17%	17%	33%	0%	33%
22	17%	50%	0%	33%	0%
24	33%	17%	33%	17%	0%
28	50%	17%	0%	17%	17%

All experts stated that improvements needed to be made on the video especially specifically technical problems on the where several videos play simultaneously, interfering with the learning process. On average the experts gave a rating of 2.17; which expert 1 gave a scale of 4 (Critical usability problem) on sub-heuristic 15 i.e. related to video handling. In terms of language, three experts found that the use of two languages; The English and Malay language in the videos displayed were inconsistent and suggested exclusive use of Malay.

Apart from video, experts also stated that audio needs to be improved to make it easier for users to better understand the content of the modules presented. Expert 2 stressed that the intonation of the narration and frequency should be consistent and added that the volume of the background noise (music, sound effects, etc.) be lowered so as not to disturb the voice of the narrator. Expert 3 also agreed that the narration was unclear and needed improvement. Background noise and the voice of the narrator are important to convey information effectively. A clear narrator's voice makes it easier for users to understand the information presented and good background noise can influence users 'interest in continuing learning [35].

Three out of six experts suggested that a search button should be placed on the interface to give users the option to search for the desired topic without having to browse the topics provided one by one. In addition, two experts argue that documentation or usage instructions should be provided if users need a reference.

5 Conclusion and future research

In line with 4IR in the field of education, this study adapted teaching methods from emerging technological developments. Studies relating to the use of Augmented Reality (AR) technology and gamification technology is an innovative effort that can improve the user experience and student engagement, especially for the subject of Biology [36]. The study resulted with the M-BioP mobile application that combined elements of gaming or gamification with the latest AR technology. Applications were tested for interface usability through heuristic checks by interface design experts. Application inspection results can be improved. This application makes learning interesting and interactive which in turn provide interesting learning experience that improves the level of understanding and academic results of students. Nowadays, teaching staff are not the sole communicators of information to students. Therefore, instructors need to adapt new teaching methods in accordance with the rapid development of technology in order to provide new generations with creative, innovative as well as competent use of technology to meet the challenges of the latest revolution. In the future, an evaluation of m-BioP will be carried out involving Biology students and teachers. Their feedbacks are important to validate the learning experience model.

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7 References

[1] Hannay, M., & Newvine, T. (2006). Perceptions of distance learning: A comparison of online and traditional learning. *Journal of online learning and teaching*, *2*(1), 1-11.

[2] Hakami, Z. (2021). Comparison between Virtual and Traditional Learning Methods for Orthodontic Knowledge and Skills in Dental Students: A Quasi-Experimental Study. In Healthcare (Vol. 9, No. 9, p. 1092). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/healthcare9091092

[3] Ramli, R. Z., Marobi N. O & Ashaari (2021) N. S Microorganisms: Integrating Augmented Reality and Gamification in a Learning Tool. International Journal of Advanced Computer Science and Applications(IJACSA), 12(6), 2021. https://doi.org/10.14569/IJACSA.2021.0120639

[4] Shrestha, P and Singh, N. (2017). Emerging Technologies for Transformation in Education Domain. Renewable Research Journal. 3(3). 361-365

[5] Eldokhny, A. A., & Drwish, A. M. (2021). Effectiveness of Augmented Reality in Online Distance Learning at the Time of the COVID-19 Pandemic. International Journal of Emerging Technologies in Learning (iJET), 16(09), pp. 198–218. https://doi.org/10.3991/ijet.v16i09.17895

[6] Thurber, D.2021. Designing Learning Experiences for the Future of Learning in the Digital Age: A Proposed Framework.Current Issues in Education.22(1). 1-18

[7] Carrier, M., Damerow, R. M., & Bailey, K. M. (Eds.). 2017. Digital language learning and teaching: Research, theory, and practice. Taylor & Francis. https://doi.org/10.4324/9781315523293

[8] Firas Layth Khaleel, Noraidah Sahari Ashaari, Tengku Siti Meriam Tengku Wook. 2019. An empirical study on gamification for learning programming language website. Jurnal Teknologi. 81(2). 150 - 162. https://doi.org/10.11113/jt.v81.11133

[9] Ibarra-Herrera, C.C., Carrizosa, A., Yunes-Rojas, J.A., & Mata-Gómez, M.A. (2019). Design of an app based on gamification and storytelling as a tool for biology courses. International Journal on Interactive Design and Manufacturing (IJIDeM), 1-12. https://doi.org/10.1007/s12008-019-00600-8

[10] Alomari, I, al-Samarraie, H dan Yousef, R. 2019. The role of gamification techniques in promoting student learning: a review and synthesis. Journal of Informations Technology Education: Research. 18. 396-417. https://doi.org/10.28945/4417

[11] MCMC Malaysian Communications and Multimedia Commission (2021, Feb, 12), Resource, Internet User Survey, https://www.mcmc.gov.my/en/resources/statistics/internet-users-survey

[12] Bergagna, E., & Tartaglia, S. (2018). Self-esteem, social comparison, and Facebook use. Europe's journal of psychology, 14(4), 831. https://doi.org/10.5964/ejop.v14i4.1592

[13] Abd Majid, N. A., & Abd Majid, N. (2018). Augmented reality to promote guided discovery learning for STEM learning. Int. J. on Advanced Science, Engineering and Information Technology, 8(4-2), 1494-1500. Tsay, C. H. H., Kofinas, A., & Luo, J. (2018). Enhancing student learning experience with technology-mediated gamification: An empirical study. Computers & Education, 121, 1-17. https://doi.org/10.18517/ijaseit.8.4-2.6801

[14] Abdul Razak, A., & Connolly, T. M. (2013). Using Games-based Learning: How it Influences the Learning Experience and Outcomes of Primary School Children. International Journal of Emerging Technologies in Learning (iJET), 8(S2), pp. 47–54. https://doi.org/10.3991/ijet.v8iS2.2782

[15] Domínguez, A., Saenz-de-Navarrete, J., De-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J. J. (2013). Gamifying learning experiences: Practical implications and

outcomes. Computers & education, 63, 380-392. https://doi.org/10.1016/j.compedu.2012.12.020

[16] Sakulwichitsintu, S., Colbeck, D., Ellis, L., & Turner, P. (2015, July). Online Peer Learning: What Influences the Students' Learning Experience. In 2015 IEEE 15th International Conference on Advanced Learning Technologies (pp. 205-207). IEEE. https://doi.org/10.1109/ICALT.2015.122

[17] Kremer, S., Sies, T., & Lindemann, U. (2016, December). Designing meaningful User Experiences: Interactive Learning Experience Model. In 2016 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM) (pp. 286-290). IEEE. https://doi.org/10.1109/IEEM.2016.7797882

[18] Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. Educational Research Review, 20, 1-11. https://doi.org/10.1016/j.edurev.2016.11.002

[19] Garzón, J., Baldiris, S., Gutiérrez, J., & Pavón, J. (2020). How do pedagogical approaches affect the impact of augmented reality on education? A meta-analysis and research synthesis. Educational Research Review, 31, 100334. https://doi.org/10.1016/j.edurev.2020.100334

[20] Neta, F., Yulius, R., & Nasrullah, M. F. A. (2020). Effectiveness of Using 2D Animation Video with Live Shoot Motion Graphic. In 2nd International Media Conference 2019 (IMC2019) (pp. 119-127). https://doi.org/10.2991/assehr.k.200325.011

[21] Santos, A., Kroll, J., Sales, A., Fernandes, P. Wildt, D. 2016. Investigating the Adoption of Agile Practices in Mobile Application Development. In Proceedings of the 18th International Conference on Enterprise Information Systems - Volume 1: ICEIS, 490-497, 2016 , Rome, Italy. https://doi.org/10.5220/0005835404900497

[22] Thomson, S. B. (2010). Sample size and grounded theory. Thomson, SB (2010). Grounded Theory-Sample Size. Journal of Administration and Governance, 5(1), 45-52.

[23] Ling, L. Y. (2003). What Makes a Good Kindergarten Teacher? A Pilot Interview Study in Hong Kong. Early Child Development and Care, 173(1), 19-31. https://doi.org/10.1080/0300443022000022396

[24] Wilson, C. (2013). Interview techniques for UX practitioners: A user-centered design method. Newnes.

[25] deMarrais, K. B., & Lapan, S. D. (2003). Qualitative interview studies: Learning through experience. In Foundations for research (pp. 67-84). Routledge. https://doi.org/10.4324/9781410609373

[26] Ramli, R. Z., Zin, N. A. M., Ashaari, N. S., Ismail, M. N., & Osman, S. (2017). Design of graphic and Animation in Game Interface Based on Cultural Value: Verification. Journal of Fundamental and Applied Sciences, 9(5S), 183-194. https://doi.org/10.4314/jfas.v9i5s.14

[27] Nielsen, J. 1992. Finding usability problems through heuristic evaluation. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 373-380). https://doi.org/10.1145/142750.142834

[28] Nielsen, J., Mack, R.L., 1994. Usability Inspection Methods. Wiley, New York. https://doi.org/10.1145/259963.260531

[29] Desurvire, H., Caplan, M., & Toth, J. A. 2004. Using heuristics to evaluate the playability of games. In CHI'04 extended abstracts on Human factors in computing systems (pp. 1509-1512). https://doi.org/10.1145/985921.986102

[30] Shneiderman, B. 2005. Designing the User Interface: Strategies for Effective, Human-Computer Interaction. Addison-Wesley Longman Publishing, Co., Inc.

[31] Jimenez, C., Lozada, P., & Rosas, P. 2016. Usability heuristics: A systematic review. In 2016 IEEE 11th Colombian Computing Conference (CCC) (pp. 1-8). IEEE. https://doi.org/10.1109/ColumbianCC.2016.7750805

[32] Wahab, N. A., Ahmad, M. R., Isa, A. A. M., Malik, R. F., & Esa, M. R. M. (2019). WiFi Temporal Coverage: Analysis of Socio-Economics Influences in Malaysia. In IOP Conference Series: Earth and Environmental Science (Vol. 228, No. 1, p. 012007). IOP Publishing. https://doi.org/10.1088/1755-1315/228/1/012007

[33] Santoso, H. B., Hadi Putra, P. O., & Farras Hendra S, F. F. (2021). Development & Evaluation of E-Learning Module Based on Visual and Global Preferences Using a User-Centered Design Approach. International Journal of Emerging Technologies in Learning (iJET), 16(15), pp. 139–151. https://doi.org/10.3991/ijet.v16i15.24163

[34] Koolidge, L., & Holmes, R. M. 2018. Piecing It Together: the effect of background music on children's puzzle assembly. Perceptual and motor skills, 125(2), 387-399. https://doi.org/10.1177/0031512517752817

[35] Khaleel, F. L., Ashaari, N. S., & Wook, T. S. M. T. (2020). The impact of gamification on students learning engagement. International Journal of Electrical and Computer Engineering, 10(5), 4965. https://doi.org/10.11591/ijece.v10i5.pp4965-4972

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