Journal of Information Technology Management

Print ISSN: 2008-5893

Online ISSN: 2423-5059

Designing a Mobile Application for Children: Space Science

Wan Fatimah Wan Ahmad*

*Corresponding Author, Ph.D., Computer & Information Sciences Department, Faculty of Information Technology and Sciences, University Technology PETRONAS, Malaysia. E-mail: fatimhd@utp.edu.my

Ain Fatihah Ahmad Harnaini

B.IT., Computer & Information Sciences Department, Faculty of Information Technology and Sciences, University Technology PETRONAS, Malaysia E-mail: ainfatihah@utp.edu.my

Abstract

The incorporation of STEM education into the curriculum has been an aspiring objective for many nations around the world. Most students choose not to pursue STEM-discipline studies because they are losing interest slowly. Moreover, the level of engagement required for STEM education is limited due to inadequate interactive teaching and tools that facilitate effective learning in a classroom setting. The objective of this project is to assess how educational game applications can help incline students' interest in science, develop an educational game application, and conduct user experience testing. A mobile application on Earth and Space Science has been developed for 10 – 11-year-old school students. The project is based on the Rapid Application Development methodology considering the short development timeframe. The application was created using the Ionic Framework, Angular 5, C#.NET and SQLExpress. The findings indicated that this experiment motivates students to be more inclined to science.

Keywords: STEM education; Earth and Space Science; Mobile Application; Educational Game.

DOI: https://orcid.org/10.22059/jitm.2022.84889 Manuscript Type: Research Paper University of Tehran, Faculty of Management

Received: January 12, 2020 Accepted: March 25, 2020

Introduction

Malaysians first introduced the Vision 2020 concept when the Sixth Malaysia Plan was tabled. Since then, Malaysia has aspired to transform itself into a fully developed and industrialised nation by 2020 (Ministry of Education Malaysia, 2017). Nine key strategic areas have been identified to achieve this vision. The first area addresses building a progressive and forward-looking society empowered by science and innovation. Instead of being mere consumers of technology, individuals will also be capable of contributing to the scientific and technical developments of the future. The roadmap for adopting STEM has been clearly outlined in the Malaysian Education Blueprint 2013-2025. It is a positive measure required to bring Malaysia at par with other developed countries (Ministry of Education Malaysia, 2017).

The recent advancements in global science education (the STEM discipline) have transformed the science education landscape in Malaysia. Science education is critical to balance knowledge breadth and depth to ensure that the younger generation and adults are encouraged to learn. They should be well-equipped to participate in scientific discussions and decision-making and facilitate advanced, in-depth study (Darling-Hammond et al., 2020). Science education is significant for providing students with the opportunities to acquire and use higher-order thinking skills (Supeno et al., 2019). Moreover, integrating technology with the educational curriculum can provide young students with the opportunities to think critically about technology, thereby leading to a technologically-literate generation (Kelley & Knowles, 2016).

According to Mahmud et al. (2018), the national science curriculum has been updated to facilitate STEM education, as envisioned by the Ministry of Education (MOE). STEM education is perceived as (a) STEM, which entails conventional disciplines like physics, and contemporary fields like biochemistry; (b) upper secondary level students selecting interest-based STEM stream; and (c) STEM pedagogical approach that emphasises students' activities directed at solving real-world problems (Ministry of Education, 2017).

STEM curriculum is used to stimulate students' interest in building skills in science, technology, engineering, and mathematics. This approach enables learners to assess the learning process concerning two or three topics (Mohamad Hisyam Ismail et al., 2019). Ironically, student participation in STEM-related fields has witnessed a decreasing trend due to the rising demand for human resources with highly critical and analytical abilities (Abd Rauf et al., 2018). This pattern can be observed from the students' enrolment that indicates an increase in the number of higher secondary students who qualify but do not choose science. As of 2018 (Ministry of Higher Education, 2017), the percentage of Form 4 students opting for science was 21.93% in 2018, compared to 23.76% in 2017. Meanwhile, the percentage of Form 4 students opting for the art stream was 55.72% in 2018, compared to 56.72% in 2017. Surprisingly, the percentage of Form 4 students opting for religion-specific streams has risen rapidly from 0.21% in 2017 to 2.21% in 2018. Based on the 2018 statistics by The Ministry of Education, 23.23% of Form 5 students opted for science in 2017 compared to 22.17% in 2018. Furthermore, 54.78% of Form 5 students opted for the art stream in 2018 compared to 53.72% in 2017. Form 5 students in religion-specific streams rose rapidly from 0.14% in 2017 to 1.56% in 2018.

The introduction of STEM education also seeks to stimulate the young generation's thinking skills as part of their learning syllabus, from pre-school to the post-graduate stage. STEM theory is currently widely practised in industrialised nations like the United States, Korea, China and the United Kingdom (Kang, 2019). STEM-based educational aims that countries relying on this philosophy will create leadership in technology and sustain economic prosperity.

The incorporation of STEM education in the primary school curriculum has been the eventual goal for several countries. Nevertheless, most global early STEM education programs rely on conventional teaching formats accessible only to a small fraction of students (Mohamad Hisyam Ismail et al., 2019). Considering the limited availability of interactive teaching and effective learning methods, numerous learners lose interest and commitment to learning STEM-based domains. It is because there is relatively low open primary school knowledge or STEM education. The chief explanation for this issue is that the curriculum typically focuses on higher education than primary education (Margot & Kettler, 2019). Additionally, there are not many high-quality tools or innovations to drive STEM education for primary school students successfully (DeJohnette, 2018).

Therefore, this paper discusses using the educational game mobile application to help build interest and motivate primary school students to learn science. An educational game has been developed for primary school-level science to increase students’ interest in learning STEM-specific subjects. This is in agreement with Abd Rauf et al. (2018), who suggested that attempts to motivate and build students’ interest in STEM subjects should begin during primary school. Using the developed mobile application, students can learn about Earth and space science topics like planets, movement of the Earth, or the phases of the moon. A mobile application based gaming environment promoting scientific, analytical, and critical thinking skills is expected to prepare students for relatively easy acceptance of substantially complex scientific concepts and topics as their study progresses.

Literature Review

Mobile Phones

Smartphones and basic mobile phones have extensively taken over the current telecommunications gadget scene, primarily because of innovative capabilities built over time (Gladden, 2018). The mobile industry is changing rapidly and extensively; consequently, smartphone penetration typically increases since phones allow people to stay online and connected to the internet practically everywhere. Based on a survey conducted by Taylor & Silver (2019), 86.9% of children below 20-years of age own a mobile phone; moreover, about 42.9% of the students undergoing primary education own these devices.

Meanwhile, at the primary school level, mobile users' education distribution stood at 11.6%. Additionally, mobile apps serving various purposes and use-cases are being created continuously to improve smartphone functionality. These applications allow the market to expand steadily. These mobile devices are commonly used for technological tasks like audio-video recording and editing, geolocation, measurement, personal efficiency, social networking, on-the-go learning, and product comparison.

Considering the rapid rise in smartphone ownership among the younger age groups and the teaching and learning benefits offered by these devices, smartphones and other mobile devices have bright prospects in the education domain. Integrating mobile technology with the education domain is lucrative because of aspects like flexibility, portability, accessibility using compact devices, high processing speed, continuous operation, and reliability. Despite their small size, such devices are very powerful and maybe comparable to devices with relatively less portability. Internet connectivity enables rapid, unrestricted information retrieval and simultaneous communication without time or location constraints (Taylor & Silver, 2019). Teaching and learning processes can benefit from well-planned strategies to integrate mobile devices in order to benefit from their capabilities.

Mobile devices like smartphones and tablets have been successful in education, especially because most individuals have already integrated mobile devices with their daily lives. Educators are now exploring the integration of these technologies with learning and teaching processes to meet educational goals. There are several projects that have established the benefits of incorporating mobile technology for higher education institutions.

Many researchers have witnessed the potential of the mobile phone as an additional tool for learning. They have investigated the possibilities of using mobile devices, using features and advancements to provide supplementary learning activities. The design and usability of educational apps align with the processes established for children's learning and growth; they promote active, engaged, meaningful, and socially interactive learning (Mohamad Siri Muslimin et al., 2017). According to another study (Gangaiamaran & Pasupathi 2017), young children are increasingly using mobile devices. They are enthralled by the idea of using these devices because they derive immense pleasure using these devices.

Numerous Mobile Applications

Numerous brands offer different mobile device models with a variety of operating systems. There are four major operating systems in the market, which are iOS, Android, Blackberry OS, and Windows. Android has a majority market share of 56%, while iOS maintains its 39% share. On the other hand, Windows Phone commands only 5% market share, and the remaining popular platforms, including Blackberry OS, comprise a meagre 0.1% of the market (Novac et al., 2017). So, iOS and Android have a monopoly because they account for 95% of the mobile OS market. Table 1 lists the prominent mobile operating systems.

Table 1. Prominent Mobile Operating Systems

Vendor	OS	Language	Environment	Application Store
Google and Open Handset Alliance	Android	Java	Eclipse	Google Play
Apple	iOS	Objective-C	Xcode	iPhone App Store
Microsoft	Windows Phone	Visual C#/C++	Visual Studio	Windows Phone Marketplace
RIM	Blackberry OS	Java	Eclipse	Blackberry App World

Approaches to Develop Educational Mobile Applications

Choosing the right development approach is important, and it directly affects the application life cycle. Several factors affect the criteria for selecting a development approach for mobile apps. Execution time is one aspect that must be considered. Several research studies illustrate the architecture and design aspects of m-learning applications. Most suggested approaches concentrated on just a few aspects of m-learning system design while ignoring other aspects like the student-specific information and selecting the right platform (García-Martínez et al., 2019). According to Nurul Farhana Jumaat et al. (2018), the learning approach has five key components: learning theories, mobile learning context, generic mobile environment, learning goals, and learning experience.

Learning theories like cognitivism, behaviourism, and constructivism are clearly important for creating learning material; however, communication methods are also crucial. (Nurul Farhana Jumaat et al., 2018). Nurul Farhana Jumaat et al. (2018) also highlighted that m-learning applications should emphasise how application design affects learners, considering that they desire a satisfactory and attractive experience while acquiring information. Furthermore, learners' goals are also important and guide application development.

ADL M-learning Architecture (Benkin et al., 2012), based on the ADDIE model, is a unique approach for creating an m-learning application, as depicted in Figure 1. This approach benefits from using Rapid Prototyping, Agile Model, and ADDIE (Analysis, Design, Development, Implementation and Evaluation) model. ADDIE is an Instructional System Design (ISD) approach that allows pedagogy, learning theories, and other instructional design concepts to be incorporated into the framework. Furthermore, the framework emphasises repetition while considering steps, m-learning architecture, learning theories, and strategies. However, this approach is ambiguous concerning m-learning design concerns; however, it provides clarity on the technological and functional considerations of the application.

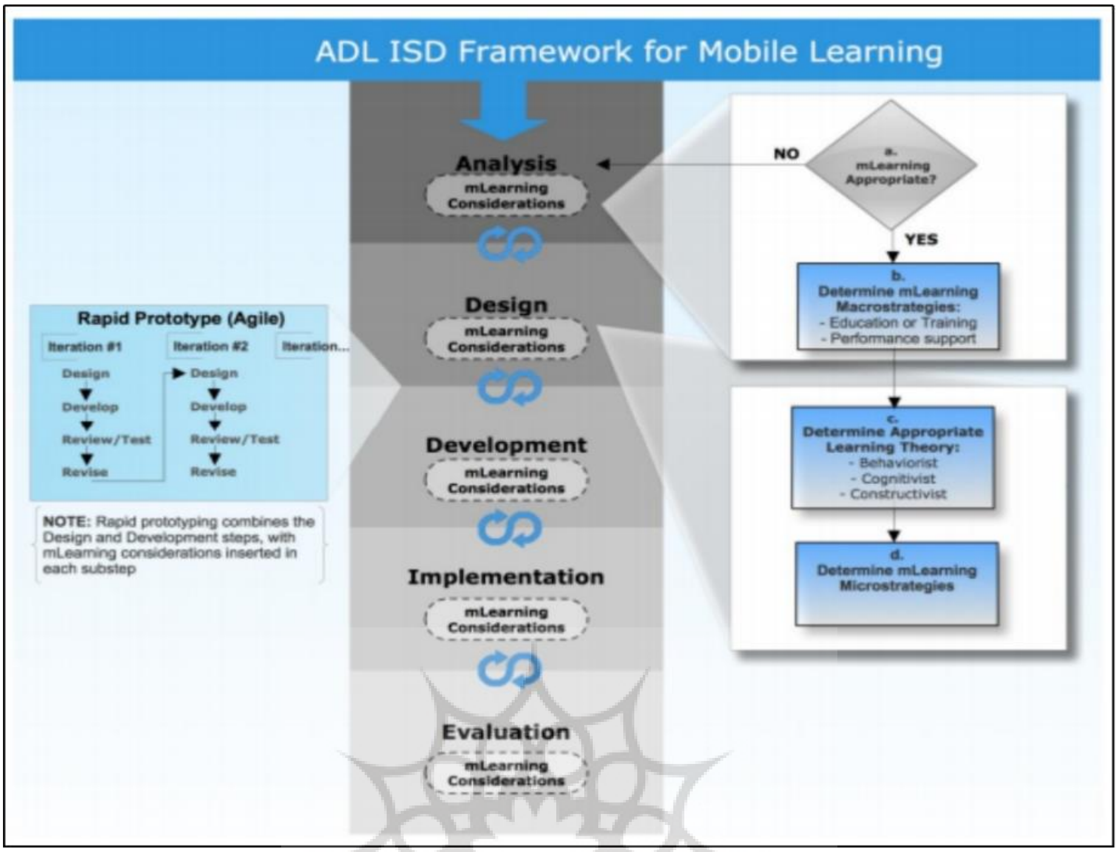


Figure 1. The Research Concept

Engagement in Gaming

Participation is fundamental to education today. Based on several theories, engagement can be defined as the value of user experience with technology characterised by sophistication, aesthetic and sensory appeal, feedback, innovation, interactivity, perceived power and time, attention, motivation, interest, and impact (His-Peng Lu & Hui-Chen Ho., 2020). This description includes engagement variables and effects but does not define engagement directly. Engagement was also defined as a sustained level of participation induced by capturing an individual's interest, keeping most of the energy of a person's attention, and putting the person in a state of immersion (Yu-Wei Chuang 2020). Instead of the engagement condition, researchers include a technical overview that describes the engagement process.

In the context of mobile games, player interaction happens when the player derives pleasure from the application. Players become "hooked" and heavily engrossed in the game to the level they want to continue playing (Chaldea & Lupiyoadi, 2018). Customer engagement for mobile games will be referred to as "player engagement" for the sake of distinction. According to Pechenkina et al. (2017), mobile apps with gamified elements integrated into their design can further engage and motivate students and facilitate learning. Engagement is of specific importance, as it may contribute to student retention.

Motivation in Gaming

Numerous researchers have suggested theories about basic human psychological needs that invoke the forces driving digital game participation. Ryan & Deci (2017) used the Theory of Self-Determination (SDT) to clarify the contribution to digital game engagement. SDT identifies three key psychological needs: a sense of intent, will and personal agency, and social interaction. It is easy to observe that digital games could fulfil these needs. It explains why people play games. Human psychological needs comprise related feelings to be felt. It is also assumed that to get these feelings deeply; players should willingly engage in a process like suspension of disbelief (Bergdahl et al., 2020). As suggested in the engagement theory, players' actions are dictated by the desired emotions. The emotions felt by gamers while playing games are the motive for playing games.

Existing Educational Games

Presently, there are several free-to-download science-related educational games on the market. Users have several choices concerning subscription or payment for application downloads. The following are some examples of educational games that can be found online.

There are 15 mini-games about English, Math, and Science offered by Dino School, as shown in Figure 2. The kids are expected to enjoy learning as much as they enjoy playing games. They can choose from a set of carefully planned activities. This application is acceptable for 5th-grade students. The game uses the dinosaur theme and provides interesting gameplay to help the students engage better with the user interface.

Nevertheless, Dino School is too general as it does not concentrate on one particular subject and topic; instead, it discusses most topics superficially. Furthermore, in-application game purchases are often necessary for players to enjoy such features. Considering that students are unable to make the purchase without their parents' or guardians' permission, very few students can access paid features.

As depicted in Figure 3, the application on human anatomy lets students study the biological structure of the human body, including processes, organs, and tissues. Challenging anatomy and physiology and smart quizzes are ad-free research games for learning various human body processes, external and internal organs, and medical terminology. The game approaches presenting tasks based on reward calculation. The score leader board is displayed, and two difficulty levels are present. However, the game content and covered syllabus are very advanced.

Figure 2. Snapshot of Dino Grade 5

Figure 3. Interfaces of Human Anatomy

As depicted in Figure 4, the Second Grade Learning Games app offers 18 mini educational games to support second-grade students with lessons like the human body, cardinal directions, geometry, and other STEM subtopics. This application is appropriate for kids between 6 and 9 years of age. This game covers a variety of subtopics related to STEM subjects rather than concentrating exclusively on one subject topic. Furthermore, students may also be forced to pay for in-application purchases possible after downloading in order to access other subjects apart from the two free subjects.

Figure 4. Interfaces of Human Anatomy

The quality of the output produced from the information system used. If the authenticity, accuracy, completeness, compactness, timeliness, relevance, comprehensibility, precision, conciseness and informativeness can be improved, the satisfaction level will increase. The better the quality of information, the better the decisions made will be. If the information produced is not quality, it will affect user satisfaction.

Increased user trust in information systems because they get benefits or uses that can help their operational performance. The benefits of information system users can be known from the trust of information system users, if the user feels that the system is useful then he will use it.

Methodology

Rapid Application Development (RAD) methodology was adopted for developing the mobile app. Qualitative and quantitative analysis techniques were used for this study. Two science teachers were interviewed to gather and assess the knowledge provided to students. The interview provides information on individual behaviour, beliefs, values, knowledge, behavioural perceptions and cases adapted from Robinson (2018). The objective of this interview session is to obtain better input from science teachers in primary school and to identify subtopics that students struggle with. The mobile app was developed after requirement gathering. The app was developed using the Ionic Framework, Angular 5, C#.NET, and SQLExpress. It focuses on Earth and Space Science for 10- and 11-year-old students. Samsung mobile phone model Note 4 running Android Marshmallow 6.0.1 was used to test the game. Twenty students conducted user experience testing.

Findings

Interview

Interview outcomes showed that educators perceive educational games as learning using media and computers, by doing and witnessing, and using critical reasoning to create a fun-filled and positive learning environment. Teachers also explained how educational games encourage continuous learning, increase opportunities, and stimulate interest in the subject. Furthermore, students are expected to feel good after playing the game because completion provides a sense of achievement. Table 2 contains the interview description.

There are some ideas for implementing the educational game; these include game design, considering the students' interest and skills. Teachers also discussed the requirement of understanding how games can be incorporated with the programme syllabus. The teachers also proposed subtopics for Life Sciences, Earth and Space Science, Material Science and Technology, and Sustainable Life.

Study results showed that teachers perceive educational games as learning through doing and experiencing, learning through media and computers, using critical thinking, and having fun. Teachers also addressed how educational games can motivate the students to remain engaged and interested in facilitating long-term learning. Furthermore, playing games helps students feel good about themselves and gives them feelings of achievement. As a result, students are more likely to participate during classes. The teachers had given some recommendations for implementing the educational game. They suggested that the games be developed considering students' interests and abilities. School administration and parents could no longer restrict teachers from introducing the educational game. Teachers also discussed the need to understand how they can incorporate curriculum syllabus into their lessons.

Table 2. Summary of the interview

No	Teacher	No of years taught	Feedback
1	Teacher 1	5.6	Educational game - can be considered as doing, experiencing, fun learning. - Supports permanent learning - Increases the motivations and interests of students about the subject - Making students happy to be part of the educational game
2	Teacher 2	6	Educational game May assist students to connect further with the method of teaching and learning. Suitable for all subjects Promotes critical thinking.

Project Flowchart

As shown in Figure 5, the suggested flow of the mobile application of the educational game consists of one set of five questions related to the sub-topic of Earth and Space sub-topic. The user will need to answer the questions within a gameplay time limit of 1 minute. Users earn coins and points for correct answers. Coins can be used to buy hints; the user must answer all questions in order to complete the game. Upon finishing, the user receives the results and accomplishments in the form of coins and points. Accumulated points are used to gain a corresponding achievement rank.

Figure 6 (b) depicts a gaming page that appears during the normal gaming mode after clicking on the "Play" button. The user can see the one-minute timer and accumulated points. Questions appear on the orange-coloured card, while the options are presented using turquoise-coloured cards for better differentiation. Two buttons above the tab bar display the hint options available to the user: buy a hint to answer the question or delete one wrong answer. If the user wants to buy hints, the accrued coins must be subtracted. After the user selects an answer, the subsequent question from the set is presented automatically.

The recovery page is shown in Figure 6 (c); it appears before the user clicks the recovery button. The user can replay on the page the last set of questions from the previous game. The application user-interface is built like a game; however, the user can see his response and the correct answer, irrespective of the answer chosen. A green-coloured card displays the correct answer; however, it is represented using the red-coloured card if the answer is incorrect. The user will see two buttons, namely, the opening of the pencil and book icons, above the tab bar. The pencil icon button will allow the user to download brief notes about the query, while the open book icon allows users to read those notes.

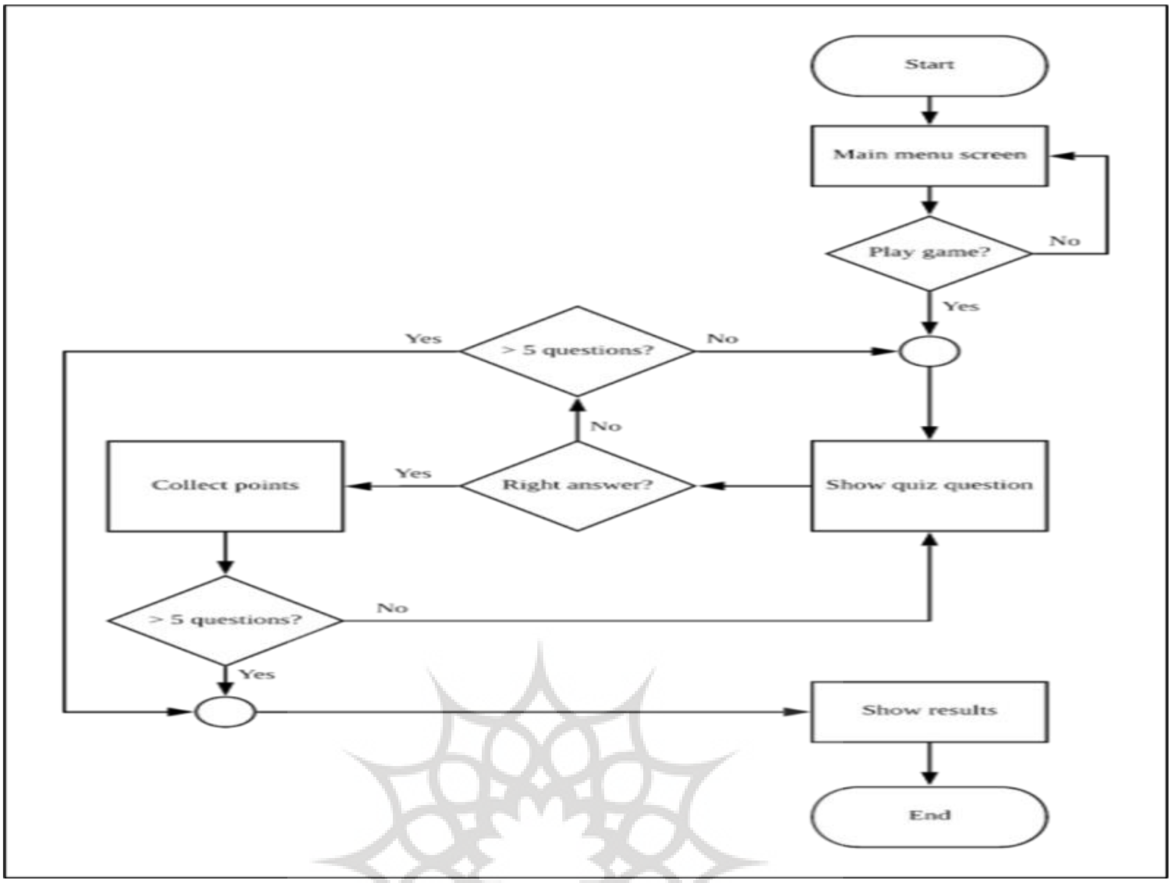
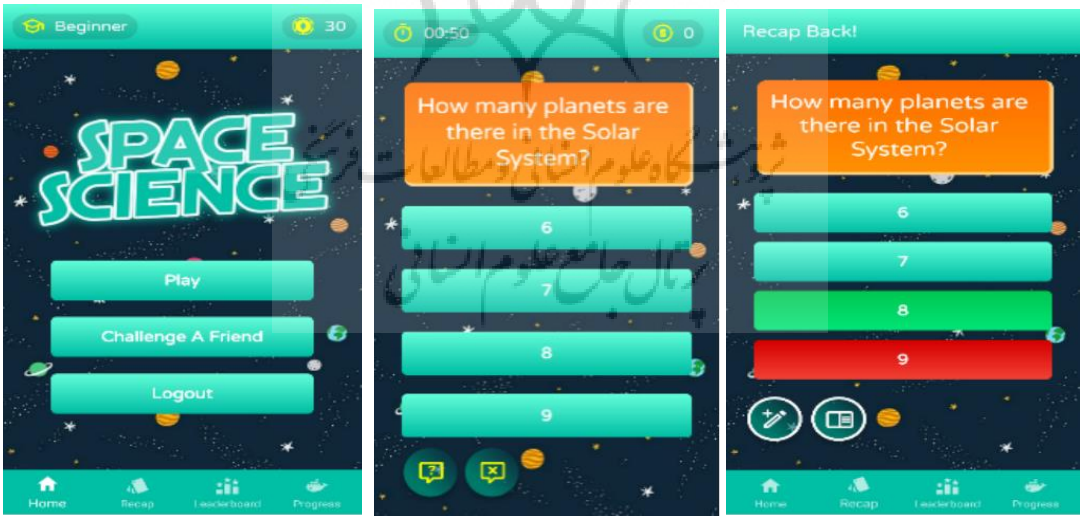


Figure 5. Game Flow



a. Main Page b. Gaming Page c. Recovery Page

Figure 6. Game Flow

Figure 7(a) depicts the result page that will be displayed when the user completes answering five questions. Similarly, if the user is yet to answer all questions, but the one-minute countdown stops, this page will be displayed. In the gameplay section, the user will be able to see the coins and points he has won for every correct answer. The user will get five coins and ten points for every correct answer. Achievements depend on the points earned by the user. An individual can progress from ‘Beginner’ achievement level to ‘Boost’ and ‘Expert’. Star mark is used with the list of questions to indicate the number of questions answered correctly by the user. The home tab can be clicked to navigate to the home page.

Figure 7(b) depicts the Leaderboard page that will be displayed when the user clicks on the Leaderboard tab. The user will be able to see on the toolbar his latest accomplishment level and points earned. The user will also be able to see the top five matches and the points scored. The player with maximum points is allocated the first position in the table.

Figure 7(c) depicts the progress page presented to the user before clicking on the Progress tab. The user can see his present achievement level, total questions answered, and total correct and incorrect responses. When a user answers all questions in gameplay sessions, he can see his knowledge level using correct and incorrect responses.

a. Result Page b. Leaderboard Page c. Progress Page

Figure 7. Space Science Mobile Application

User Experience Testing

User experience testing was carried out to determine if the target users received the mobile application as expected. The User Experience Questionnaire (UEQ) proposed by Robinson (2018) was adopted in this study. The questions were circulated shortly after concluding the user experience testing session. Twenty fifth-year students were selected randomly. They were asked to play the Space Science game prototype and provide their responses on a five-point Likert Scale.

Table 3 shows the result summary. 85% rated the app as easy to read, while 80% rated it positively for using it as a teaching and learning tool. Findings show that 75% of the students rated 'Agree' on user-friendliness and ease of use, user interface design, context understanding effectiveness, and encouragement of the mobile application's competition. Few students who have not used mobile phones and computers extensively were identified; these students belonged to less-privileged families. Some suggestions include using animations and sound effects, using a dual language system, including "hints" because the software is built-in English. Overall, most students liked the games. This mobile app is a suitable way to add exciting educational elements to the classroom.

Table 3. Summary of the interview

No	Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	user-friendliness and ease of use			10%	75%	15%
2	user interface design		10%		75%	15%
3	Easy to read				85%	15%
4	Easy to play		10%	15%	65%	10%
5	Efficiency in understanding context		10%	5%	75%	10%
6	Efficiency in answer cues		10%	10%	65%	15%
7	Effectiveness in reviewing past questions		10%	5%	70%	15%
8	Motivation of competition			10%	75%	15%
9	Useful as a teaching and learning tool				80%	20%

Discussion

Considering today's rapid technology growth, science teachers should equip themselves with ICT skills that help them incorporate ICT with teaching. For instance, ICT integration in learning or teaching science involves the use of mobile applications, augmented reality, holograms, and drones. Incorporating technology for teaching science can encourage students to research subjects. This assertion supports STEM's core concepts about technology and creativity (Siti Nur Diyana Mahmud et al., 2018). Furthermore, ICT can assist teachers in creating an effective and meaningful learning experience for their students. Consequently, ICT will improve students' involvement (Siti Nur Diyana Mahmud et al., 2018). Developing ICT skills and emphasising practical ICT aspects should be incorporated into science education. Findings indicate that mobile applications provide benefits like easy knowledge access, different learning forms, contextual learning, better control, enhanced engagement, and increased motivation. These aspects lead to substantial academic benefits. This study is in line with His-Peng Lu & Hui-Chen Ho., (2020) and Bergdahl et al., (2020) findings.

Conclusion

This paper presented a smartphone-based educational game for primary school-level science. It focused on improving teaching and learning processes in the classroom setting to help focus students' attention. Moreover, in the context of learning science, it creates interest and enhances participation among primary school students. This educational game will help kids learn while having fun using interesting gameplay. Introducing technology to children during primary education allows better adaptation to new technology. Children having technologically innovative ideas should be appropriately educated since they can use mobile applications to adapt to new learning and teaching techniques. Studies conducted for continuing similar projects present a strong chance to enhance its reach to suit several age groups. Also, the game can be made more impressive and challenging by building a database to store questions.

Consequently, children will want to play more and still not lose interest. Further developments should enhance the graphical design. A 3-dimensional game version can be created to build more interest and a better user experience. These suggestions are for works that expand or continue this project since the current project could not incorporate these aspects. These elements are important to make this game more engaging and enjoyable.

Conflict of interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

Abd Rauf, Rose Amnah Sathasivam, Renuka V. Abdul Rahim, Suzieleez Syrene & Rasul, Mohamad Sattar. (2018). STEM build program: An initiative towards promoting students thinking and communicative skills. In: Association of Southeast Asian Institution of Higher Learning (ASAIHL), 6-9.

Berking, P., Birtwhistle, M., Gallagher, S., & Haag, J. 2012, "Mobile learning: Not just another delivery method". Proceedings of the 2012 Interservice/Industry Training, Simulation and Education Conference.

Bergdahl, N. J. Nouri, J. & Fors, U. (2020). Disengagement, Engagement, and Digital Skills in Technology-Enhanced Learning. Educational and Information Technology, 25, 957–983.

Chaldea, N. & Lupiyoadi, R. (2018). Driving Mobile Game Engagement: Factors and User Metrics, 3rd Asia-Pacific Research in Social Sciences and Humanities (APRiSH 2018), Advances in Social Science, Education and Humanities Research, Volume 348, 267-274

Darling-Hammond, L, Flook, L., Cook, C. Barron, B. & Osher, D. (2020). Implications for Educational Practice of the Science of Learning and Development. Applied Developmental Science, 24(2), 97-140.

DeJarnette, N.K. (2018). Implementing STEAM in the Early Childhood Classroom, European Journal of STEM Education, 3(3), 18.

Gangaiamaran, R. & Pasupathi,M. 2017, Review on Use of Mobile Apps for Language Learning, International Journal of Applied Engineering Research, 12(21), 11242-11251.

Garcia-Martinez, I., Fernandez-Batanero, J. M., Sanchiz, D. C. & Rosa, A. L. (2019). Using Mobile Devices for Improving Learning, Sustainability, 11, 6917, MDPI.

Gladden, D'Juan. (2018). The Effects of Smartphones on Social Lives: How They Affect Our Social Interactions and Attitudes. OTS Master's Level Projects & Papers. 586. https://digitalcommons.odu.edu/ots_masters_projects/586.

His-Peng Lu & Hui-Chen Ho. (2020). Exploring the Impact of Gamification on Users' Engagement for Sustainable Development: A Case Study in Brand Applications, Sustainability, 12, 4169. 6, pp. 1-19.

Kang, NH. (2019). A review of the effect of integrated STEM or STEAM (Science, Technology, Engineering, Arts, and Mathematics) Education in South Korea. Asia Pacific Science Education. 5, 6, 1-22, Springer Open.

Mahmud, S.N.D., Nasri, N.M., Samsudin, M.A. (2018). Science teacher education in Malaysia: challenges and way forward. Asia-Pacific Science Education. 4, 8, 2-12.

Margot, K.C. & Kettler, T. (2019). Teachers' perception of STEM integration and education: a systematic literature review, International Journal of STEM Education, 6(2). 1-16. Springer Open.

Ministry of Education Malaysia (2017). Malaysia Education blueprint 2013-2125: Annual Report 2016. Putrajaya: Ministry of Education Malaysia.

Mohamad Hisyam Ismail, Muhamad Furkan Mat Salleh & Nurul Akmal Md Nasir. (2019). The issues and Challenges in Empowering STEM on Science Teachers in Malaysian Secondary Schools. International Journal of Academic Research in Business & Social Sciences, 430-444.

Mohamad Siri Muslimin, Norazah Mohd Nordin, Ahmad Zamri Mansor & Melor Md Yunus. (2017). The Design and Development Of Mobieko: A Mobile Educational App For Microeconomics Module, Malaysian Journal of Learning and Instruction: Special Issues 2017: 221-255.

Novac, O. C., Novac, M, Gordan, C. , Berczes, T. & Bujdosó, G. (2017). Comparative study of Google Android, Apple iOS and Microsoft Windows Phone mobile operating systems, 14th International Conference on Engineering of Modern Electric Systems (EMES), Oradea, 154-159.

Nurul Farhana Jumaat, Zaidatun Tasir, Noor Hidayah Che Lah, Zakiah Mohammad Ashari. (2018). Students' Preferences of M-Learning Applications in Higher Education: A Review, Advanced Science Letter. 24, 2858–2861, American Scientific Publishers.

Pechenkina, E, Laurence,D., Oates, G., Eldridge, D. and Hunter, D. (2017). Using a gamified mobile app to increase student engagement, retention and academic achievement, International Journal of Educational Technology in Higher Education, 14:31, 1-12. Springer Open.

Robinson, R. S. (2018). Sampling in Interview-Based Qualitative Research: A theoretical and Practice Guide. Journal Qualitative research in Psychology, 11(1), 25-41.

Ryan, R. M. & Deci, E. L. (2017). Self-determination Theory. Basic Psychological Needs in Motivation, Development and Wellness. New York, NY: Guilford Press.

Siti Nur Diyana Mahmud, Nurfaradilla Mohamad Nasri, Mohd Ali Samsudin and Lilia Halim. (2018). Asia-Pacific Science Education 4:8.

Supeno, S., Sri Astutik, Bektiaro, S., Lesmono, D. & Nuraini, L. (2019). What Can Students show about Higher Order Thinking Skills in Physics Learning. IOP Conference Series Earth and Environmental Science, 243(1), 1-10. IOP Publishing.

Taylor, K. & Silver, L. (2019). Smartphone Ownership Is Growing Rapidly Around the World, but Not Always Equally. Global Attitudes & Trends.

Yu-Wei Chuang. (2020). Promoting Consumer Engagement in Online Communities through Virtual Experience and Social Identity, Sustainability, 12, 855, MDPI.

Bibliographic information of this paper for citing:

Wan Ahmad, Wan Fatimah, & Ahmad Harnaini, Ain Fatihah (2022). Designing a Mobile Application for Children: Space Science. *Journal of Information Technology Management*, Special Issue, 124-140.