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Moon Phases: A Brief Overview of Android Application Development in Science Subject

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ABSTRACT

Moon phases are the part of the moon shape that is directly illuminated by the sun as seen from the earth. The moon phases change gradually in about 27 days as the positions of the moon's orbit around the earth and the earth's orbit around the sun shift. The part of the moon that can be seen is from the reflection of sunlight and it depends on the position of the moon in its orbit. However, most students do not clearly understand the concept of moon phases and were unable to explain the factors that influence the occurrence of moon phases, identify changes in the shape of moon phases, sketch the order according to the sequence of moon phases and name the moon phases. As a result, the purpose of this research is to create an android application for the moon phases topic, which also serves as a medium of teaching aids for teachers and students. The foundational knowledge elements through the 3x3 Model of 21st Century Learning have been embedded through this android application. The methodology used in this study was based on design and development research (DDR) and the ASSURE instructional model has been used as a guideline in developing this android application. Respondents that were selected to evaluate the functionality of this android application through purposive sampling technic were six (6) expert evaluators within primary school science teachers and multimedia lecturers that have extensive knowledge and experience in their field of study. Besides, three students were also selected as a user to figure out their acceptance level of this android application. A checklists form was given to them to evaluate the functionality of this android application in terms of its content, interaction and interface design as the data obtained is in the form of frequency and percentage. The results of the study showed that all experts agree that the content of this android application is easy to understand, the interaction design of this android application is suitable for the student's learning needs and the interface design was animated in an interesting way that also suitable for the use by the targeted users. As such, this android application seems to be useful as one of the teaching aids for science subjects in attracting students' interest, especially in the moon phases topic and is expected to provide a positive impact in terms of functionality and usability of android application in the present and also in the future.

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1. Introduction

Science education has been regarded as a center for knowledge economy and intellectual development, especially for students. Of the importance of science and technology, most schools have made it compulsory for every student to study science subjects [1]. Science education is the teaching and learning of science to non-scientists, such as school children, college students, or adults in public. The field of science education includes work in science content, science process (scientific method), social science, and some teaching pedagogy. Science education standards provide hope for the development of understanding for students throughout their primary education course and beyond. The traditional subjects included in the standard are physical, life, earth, space, and human sciences [2]. In primary science education, moon phases are one of the topics that are quite difficult for students to understand. In this topic, students need to first understand the phenomenon of the moon revolving around the earth. The movement of the moon around the earth causes humans on earth to observe the different shapes of the moon called moon phases [3].

Additionally, science curriculum education in Canada and United States has no exception in studying the moon phases topic and should be studied by students aged 10 to 14 years [4]. Moon phases are the part of the moon shape that is directly illuminated by the sun as seen from Earth. The phases of the moon change gradually in about 27 days as the positions of the moon's orbit around the earth and the earth's orbit around the sun shift. The part of the moon that can be seen is from the reflection of sunlight and it depends on the position of the moon in its orbit. Chastenay and Riopel [5] stated that most children in primary and secondary schools do not clearly understand related to the concept of moon phases. This may be due to various factors such as concept description, student experience, and teaching and learning process whether formal or informal. This is supported by Aznan and Haron [6] that found the results from their post-test research showed that most of the marks obtained by the students were weak. Most students could not explain the factors that influence the occurrence of the moon phases, identify changes in the shape of the moon phases, draw the order according to the sequence of the moon phases and name the moon phases [6].

Some students show boring facial ripples and are not interested in learning this concept as they give a negative response during the teaching and learning process [7]. This is supported by Sugrah [8] who argues that traditional teaching methods are no longer relevant in explaining abstract concepts in science education. In addition, it is difficult for students to understand why the moon changes shape according to the change of the lunar period by simply relying on school textbooks more a brief description without explaining the phenomena that occur [9]. The traditional teaching approach with only emphasis on remembering facts is no longer relevant used to explaining abstract concepts because according to the effect of remembering facts will result in a decrease in students' critical and creative thinking skills [10]. At the same time, it also causes students to lose focus and easily feel bored following the learning sessions conducted and even makes them passive learners [11].

Therefore, teachers should use suitable teaching approaches to ensure the effective delivery of information to students. In addition, students are unable to understand the concept of abstract learning content by simply relying on the use of textbooks or teachers' reading text in front of students who only listen to what has been read which has become a less efficient learning approach. Effective learning can be achieved through active learning and not direct instruction [12]. Accordingly, the advancement of technology in this age of globalization makes the use of technology appealing and even brings about many changes that directly affect society and individuals in understanding foundational knowledge. As such, technological advancements have transformed the education sector by bringing significant changes as a result of the Covid-19 pandemic towards the

transformation of online learning in the entire world [13]. Android application-based learning media have provided learning materials for students to learn independently. The use of learning media can guide students to be independent as mobile learning is a new direction in pedagogy and education, which is supported by Lin *et al.,* [14] who argue that mobile learning can help students and teachers access information quickly. Learning android applications can help them create foundational knowledge and understanding at a continuous level and even help motivate students to learn and interact in the learning process so that they can learn independently.

Students can be drawn in by learning android applications that use multimedia elements, particularly on smartphones. Furthermore, in today's increasingly advanced digital era, students must be given the freedom to find and manage information to learn. All information is easily accessible and at your fingertips. This indirect self-access learning can be used in tandem [15]. Furthermore, mobile learning can support the construction of foundational knowledge by enhancing critical thinking and creativity, both of which can contribute to the learning process. The teaching and learning materials delivered via these mobile learning android applications include graphics, animations, text, audio, and video to encourage students to interact with them [16].

Among the studies on mobile application development in Malaysia was one by Abd Rahman *et al.,* [17], which resulted in the development of a mobile application for the Malay Translated Hadith Search Engine. Yahaya *et al.,* [18] focused on the study of a mobile application development known as the "Dialogue Trilogy Games" to solve the problems that students face when attempting to master three languages, Arabic, English, and Malay, at the same time in their daily conversations. Additionally, a learning software called M-Lang was developed to help international students in Malaysia to learn Malay in a study conducted by Shawai and Almaiah [19].

Furthermore, there is a mobile application in the Islamic Education subject that is specifically designed for students with hearing impairments and the deaf to perform 'ibadah of prayer [20]. Meanwhile, Ariffin *et al.,* [21] have created a mobile application called Calculic Kids as a supportive learning tool for children with math difficulties, also known as Dyscalculia. In higher education, Muslimin *et al.,* [22] reported that MobiEko, an Android version of a mobile learning application, has been developed as a teaching and learning tool for economic subjects with a flexible framework.

Smartphones are not only used for educational purposes, such as learning science, but they are also used as a medium of communication, entertainment, and many other things. For instance, the iTourism application has been developed for Malaysian tourism to improve its performance in promoting Malaysia both locally and internationally [23]. Besides, there's also a prototype image-based food diary mobile application (food app) that has been developed to enable electronic dietary assessment among Malaysians [24].

The meaning of knowledge is about knowing, anything that is known, cleverness, wisdom, and knowledge, which is everything that is known or learned about something. Based on knowledge requirements as a determinant of responsibility, this means existence and the absence of responsibility depend greatly on the absence of responsibility [25]. Consequently, knowledge has a relationship that is relative to responsibility, which is the absence of knowledge means the absence of responsibility, and the existence of knowledge means the existence of responsibility. On the other hand, knowledge management consists of various strategies used in organizations to create, represent, analyze, distribute and enable the use of experience. It focuses on competitive advantage and improving organizational performance [26].

In all receptions, there is a common idea: something important that acts as a determining factor. This idea is valued in any learning process. When learning something, we need to start with the simplest aspects, known as foundational knowledge. Over time, we gain skills, experience, and practice. Finally, we will be very good at something (experts, qualified professionals, or teachers in

the discipline). If the foundational knowledge is not obtained correctly, due to precipitation, the learning results will not be satisfactory. As such, the foundational knowledge may vary over time, although the main idea remains the same.

Foundational knowledge is a database used for knowledge sharing and management. It encourages the collection, organization, and acquisition of knowledge. Many knowledge bases are structured around artificial intelligence and not just store data but find solutions to further problems using data from previous experiences stored as part of the knowledge base [27]. Therefore, the foundational knowledge management systems rely on data management technology consisting of relational databases and data warehouses. Some knowledge bases are little more than indexed encyclopedias of information; others are interactive and behave/react according to input requested from the user. Thus, the purpose of this research is to create an android application for the moon phases topic, which will also serve as a medium of teaching aids for teachers and students. The foundational knowledge elements through the 3x3 Model of 21st Century Learning have been embedded through this android application [28]. The methodology used in this study was based on design and development research (DDR) and the ASSURE instructional model was used as a guideline in developing this android application.

2. Methodology

The research methodology describes the methods and approaches used in the process of developing android applications so that the development is done in a planned manner and follows the rules that have been planned. Therefore, the researcher needs to select an appropriate model to be used as a guide. This study has employed design and development research (DDR) of an android application. The design of this android application was based on the DDR form proposed by Brown and Collin in the 1990s and ASSURE instructional model that has been introduced by Heinich *et al.,* [29] as this instructional design model is used to plan the use of media systematically. ASSURE means to ensure learning takes place as this ASSURE model can assist teachers in planning learning that utilizes the use of media in the teaching and learning process. According to Eva [30], the ASSURE model is a learning model that used media and technologies such as printed media, exhibition media, audio media, animated graphics, multimedia, and web or internet-lined media. This is intended to help reduce errors while developing the product and improve the performance of the developer throughout the production of the product. Additionally, according to the DDR approach, there are three main phases, as illustrated in Table 1.

Table 1
Implementation of DDR phase

Phase	Type of development
Phase 1: Requirement analysis	Literature review
Phase 2: Design and development	Development of the android application
Phase 3: Functionality	Quantitative method (Checklist form)

2.1 Sampling

Purposive sampling was used in this study to select the students and experts, to cover a broad range of potentially relevant social phenomena and perspectives from an appropriate selection of data sources (Azizi, 2015). As a result, three (3) standard 5 primary school students were chosen as users to determine their level of acceptance of the moon phases android application in supporting the learning process, as well as six (6) experts comprised of primary school science teachers and

multimedia lecturers. The questionnaire was given to six experts consisting of science teachers from a primary school and creative multimedia lecturers from a higher learning institution who have extensive knowledge and experience in their field of study to evaluate the android application in terms of functionality via a checklist form.

In the context of this study, the term expert was intended and grounded on specific requirements such as academic qualification, experience, subject matter, and practical knowledge in the field of practice. As a result, the selected experts had to meet the following criteria: (i) had at least three (3) years of teaching experience, (ii) had at least a degree certificate, career, or credibility in the field of science subject and creative multimedia, and (iii) be knowledgeable and understand the Moon phases concepts. By this, the intended expert has characteristics such as knowledge and skills in the field taught, the ability to operate tools and equipment used in the teaching and learning process, experience working in the required environment, experience using tested learning systems, and a willingness to participate in ongoing studies (Stevenson, 2020). Quantitative analysis has been utilized to obtain more effective and accurate information and data for this study.

2.2 Instrument

This study involved three (3) primary school students, three (3) primary school science teachers, and three (3) multimedia experts to use and evaluate the android application. The expert checklist form is given to them during the evaluation process for the functionality of the android application that has been developed to determine whether it achieves the objective of the study. In the checklist form, Part A consists of respondent demographics detail (6 items), Part B consists of items (7 items) for android application interaction design and Part C consists of items (13 items) for android application interface design. The instrument to be used by the developer is a checklist form. It is a very simple and useful technique to analyze data at different levels and the scope of a particular skill or procedure. The checklist used is a dichotomous assessment technique, which generally only accepts "yes" or "no" options. Through this method, the checklist can be a very accessible and quite practical tool [31]. On the other hand, it can also limit the evaluation criteria to very specific learning. The researchers opted to use this technic as it was easier to collect data and would provide accurate assessment in explaining respondents' feedback. The validity of the checklist form has been done by two (2) experts who have extensive knowledge and experience in the field of study. The data obtained will be analyzed using quantitative methods to show the value of the evaluation given by the respondents.

2.3 Data Analysis

In this study, the data were collected and analyzed by using frequency and percentage based on a checklist form that has been distributed. To facilitate data analysis, each item was classified and recorded as percentages. By using Microsoft Excel, the percentage used to obtain the reading of agreement level regarding the android application and classifies into different determinant levels. The data was then analyzed by using descriptive statistics to see the percentage score of experts' level of agreement throughout the checklist form given.

2.4 The Design and Development Phase

The ASSURE model introduced by Heinich *et al.,* [29] has been used to plan the systematic use of media in developing this android application. This model has 6 levels which are (i) Student Analysis,

(ii) Setting Learning Objectives, (iii) Select Methods, Media, and Materials, (iv) Use Media and Materials, (v) Engage Students in Learning, and (vi) Evaluation and Review. This model is oriented towards the teaching and learning process that can motivate and improve student learning outcomes. Therefore, developers need to follow the processes found through the model in developing an educational product to ensure a smooth android application development process. The methodological chronology was carefully and systematically been implement through activity from the initial stage of the project until the final stage after the project development was completed. Figure 1 shows the implementation of ASSURE instructional model in the development of this android application.

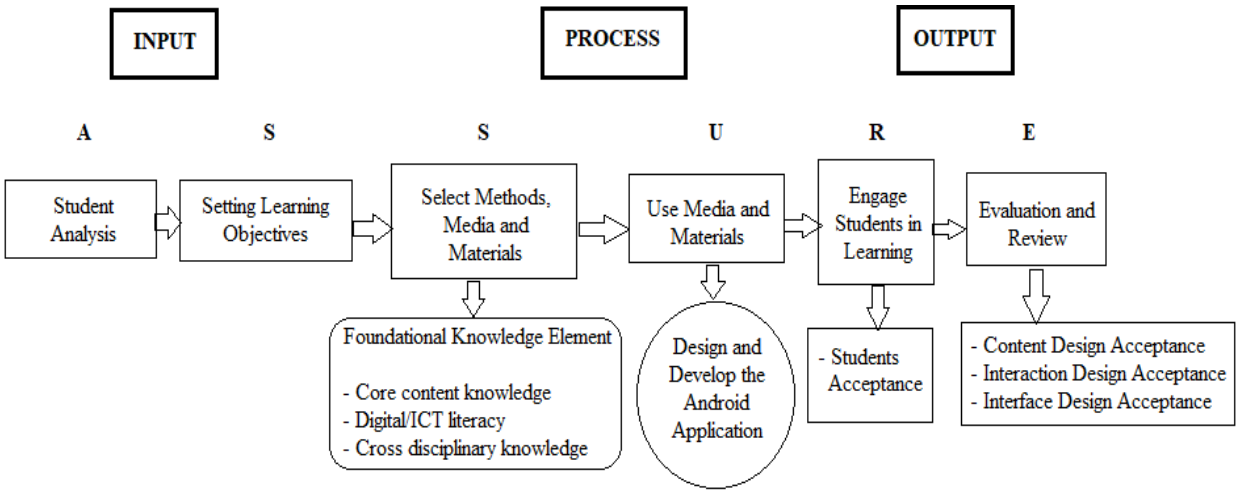

Fig. 1. ASSURE instructional model implementation in android application

In addition, the foundational knowledge element based on the 21st-century learning model consists of core content knowledge; digital/ICT literacy and cross-disciplinary knowledge have been integrated within the android application. Foundational knowledge is also known as facts, theories, and principles that are essential to more advanced or independent learning in an academic discipline. It is a basic knowledge of what students need to know that allows them to acquire foundational knowledge, theories, and perspectives in a variety of disciplines. The three key subcategories in foundational knowledge were core content knowledge; digital/ICT literacy and cross-disciplinary knowledge. Core content knowledge was characterized by highly complex and deeply ingrained mental processes specific to traditional domains. Excellence in the academic domain especially in science subjects was considered to be the foundation of students' success. Then, digital/ICT literacy can be defined as the ability to effectively evaluate, navigate and construct information using a range of digital technologies and thus function fluently in a digital world. Lastly, cross-disciplinary knowledge involves the ability to understand, organize and get involved in other fields of study, such as interdisciplinary advanced work. Although the foundational knowledge element is very general for reporting actual practices in classrooms, the feasibility of using this part of the model for designing the android application is emphasized.

The ASSURE model has a solid foundation as a guide for the construction of teaching and learning media materials. This is because based on past research, this model not only provides guidance to teachers in teaching and learning, but the features contained in this model can change students' perceptions of the teaching and learning process which is often said to be uninteresting. If this ASSURE model is used fully in preparing and building android applications for teaching and learning, certainly, the students will always wait for the arrival of the teacher to teach and teaching will be easier, more interesting, and more effective. Therefore, the teacher's skills in implementing teaching

and learning based on objectivism or constructivism will ensure that the learning outcomes of the day are achieved. The preparation and teaching aids are very important for students to enjoy following the teaching of the subject. Whether it is teacher or student-centered teaching, the implementation of activities and the active involvement of students can be seen based on the student's interest in the teacher's teaching. Furthermore, the ASSURE model provided users with a method of instructional design that included an iterative process of all the necessary phases in creating a successful course or program. The ASSURE model methods contain six (6) key phases that were used as guidance for product development in this process.

2.4.1 Student analysis

User analysis is the first phase of the ASSURE model and the most important stage. At this stage, the developer needs to determine the scope of the subject by finding information and problems from past studies and whether the topic of this study needs a solution or not. After searching for information and problems from past studies, the developer found that most students could not understand the concept and how the moon phases phenomenon occurs. In addition, the developer also set the target group required to ensure that the objective of this android application is achieved. The target users for the development of this android application were standard 5 primary school students that comprise science subjects. At this stage, the developer also determines the multimedia elements that will be applied in the development of the android application. It aims to ensure that the scope and content can help students in understanding the moon phases topic.

Then, the ASSURE model suggests 5 principles in the use of media that have been taken into account in the development of this android application, namely media preview, ensuring that the media is not problematic, determining the location, determining the students, and ensuring that the media is capable of providing new experiences to students. The use of media based on the 5 principles above can produce effective teaching and learning. The selection of software that will support the development of the android applications must be suitable to achieve the learning objectives by applying multimedia elements. The software used in developing the android application is Adobe Animate CC 2019, Adobe Illustrator, Adobe Photoshop CS6, and Wondershare Filmora 9. Next, a storyboard is needed to facilitate the development process of the android application. Storyboards become the main reference in developing user-friendly learning android applications as well as android application content in line with the user's learning syllabus. The researchers have gone through the process of creating a storyboard based on the findings of the overall investigation and data collection. The storyboard was created using Microsoft Word as a sketching tool because it is simple to use, as well as tidy, and easy to read.

Choosing to teach and learning resource materials should be guided by the content of the lesson which is the learning goal. Materials that don't involve students actively will cause students to be passive and ineffective. The selection and preparation of materials that are creative and able to stimulate students can foster interest and a culture of thinking. Thus, content, interaction, and interface design were the three categories of the design described by the researchers to deliver the learning resource effectively. This is a very necessary phase in teaching and learning through this android application to achieve the teacher's objectives. This process should be carried out carefully so that the objectives of the study can be achieved.

2.4.2 Setting learning objectives

The objectives must be explicitly stated so that they were easily measurable and achievable. Before learning begins, determining the objective is very important so that the developer can set the target to be achieved and then determine what the student can achieve. The objective for the development of this android application is to overcome student learning problems for the moon phases topic by providing learning alternatives that were aided by mobile technology for their teaching and learning process. Next, the process of developing the android application that features content, interaction, and interface design. In addition, this android application also applies the student's learning style because this android application contains multimedia elements such as text, graphics, audio, and animation. There are three types of learning styles namely visual, auditory and kinesthetic. Table 2 shows the selection of analysis in design criteria that need to be considered in this phase [32].

Table 2
Selection of analysis in design criteria

Criteria	Explanation
Functionality	This design should have an operational value where the design developed fits or meets the scope of the study.
Controllability	Students need to manage the products that are guided by the manual provided so that the operation of the production system can be shown.
Design	The development of the android application must be compatible with the functions and operating methods used for teaching and learning purposes.
Agility	The selection of materials for the development of the android application must be taken into account since it also involves the product's durability and function properly.
Economic	The cost, time, and energy of the android application development are quite high but, in reality, it is affordable with its functionality as an effective tool for teaching and learning purposes.

2.4.3 Select methods, media, and materials

The selection of methods, media, and materials must be appropriate for the user in achieving learning objectives. Choosing the appropriate method in a lesson from various methods is important to be adapted in teaching and learning activities through this android application. The researcher needs to be able to draw the student's attention to the induction set based on the student's existing knowledge. The method of discussion, training, and drills can be carried out as a method of unearthing new knowledge through this android application. It is a basics knowledge of what students need to know that allows them to acquire foundational knowledge, theories, and perspectives in a variety of disciplines Thus, the foundational knowledge element based on the 21st-century learning model consists of core content knowledge; digital/ICT literacy and cross-disciplinary knowledge have been integrated within the android application as in Table 3:

Table 3
Android application design through the foundational knowledge element

No	Foundational knowledge element	Display and description
1.	Core content knowledge	Core content knowledge was characterized by students who have to develop understanding through this application and use it to identify and apply principles and facts, the definition of terms, comparison of conceptual differences, and generate creativity, as shown in Figure 2 below

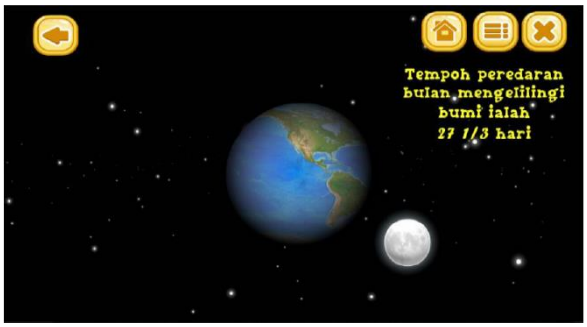

Fig. 2. Display of core content knowledge

2.	Digital/ICT literacy	Digital/ICT literacy through this application includes the skills of using and exploring this application in understanding the moon phases topic, as shown in Figure 3 below

Fig. 3. Display of digital/ICT literacy

3.	Cross-disciplinary Knowledge	This application provides and manages a climate and learning environment that is conducive and leads toward learning that emphasizes cross-disciplinary knowledge, as shown in Figure 4 below

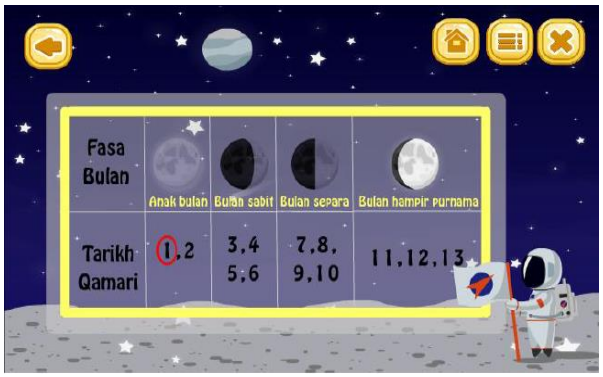

Fig. 4. Display of cross-disciplinary knowledge

2.4.4 Use media and materials

The selection and use of materials and media through this android application will be attractive and provide a suitable environment for student learning. However, in the selection and use of this android application, teachers need to ensure compatibility with the students' existing experience. In the development of this android application, the developer uses multimedia elements such as text, graphics, audio, and animation to make the learning method more interesting in addition to being able to improve student understanding in learning the topic of moon phases.

In this phase, the researchers will follow the science syllabus which is moon phases as a base where the user will learn theoretically. The development phase is implemented after the design phase is completed. This level involves many activities that include interface and content development followed by embedding multimedia elements such as text, graphics, audio, and video. Interface design is very important because it involves an initial overview of the user's android application and the development process should be carefully implemented so that it can adapt to the subject and meet the target users' objective.

Next, content development will be carried out carefully. This process should be carried out carefully so that the objectives of the study can be achieved. The multimedia elements available in this android application include video, graphics, audio, and text as the effective use of quality graphics can boost students' motivation in focusing through this android application courses. The implementation of multimedia elements is an important component of the android application as it can give the user an enjoyable learning session, especially in terms of understanding the passage time of the topic. Table 4 shows the android application design steps that explain the preparation and planning process for the main components and consumables.

Table 4
Android application design steps

No	Design	Display and description
1.	Content design	Content design is the process of explaining the purpose of the android application and organizing the content into a design that can help to achieve the purpose of the android application development. The content in this android application includes objectives, user manuals, notes on the topic, exercises, and credit, as shown in Figure 5 below

Fig. 5. Display of content design

2.	Interface design	The interface design is the main link to the user in displaying the android application page that has been developed as it creates fewer problems, increases user involvement, perfects functionality, and creates a strong link within the android application, as shown in Figure 6 below

Fig. 6. Display of interface design

3.	Interaction design	The interaction design is the navigation of this android application that allows full control of the value of a communication service to its users and the quality of experience they have when using it, as shown in Figure 7 below

Fig. 7. Display of interaction design

2.4.5 Engage students in learning

At this stage, the android application provided as teaching material will be used or implemented in real situations. The completed android application will be tested on real users to identify errors during project development. This phase will be implemented after the completion of the development phase. This stage involves the process of testing the effectiveness of the students who use it. Previously, an affiliate verification android application was required to determine whether the android application complied with the validity of the course syllabus adopted by students. Thus, the teaching materials provided will be used or implemented in real situations. If an error occurs, it will be fixed before handing it over completely to the user. The provision of creative android applications that are capable of attracting students' interest indirectly fosters the student's thinking culture and further ensures that learning objectives can be achieved.

To ensure that the learning process runs through this android application, students need to be actively involved in learning activities. This method is called student-centered learning where this method can stimulate their mind and behavior. Immediate reinforcement should be given to students who give the correct response. This is a method of stimulating or motivating students to attract interest and then actively participate in activities through this android application. Passive students will also be included to be involved. However, teachers need to ensure that class control is in good condition so that the learning process does not become uncontrolled which may cause learning objectives not to be achieved.

2.4.6 Evaluation and review

Evaluating is a process to see the effectiveness of the teaching and learning process carried out through this android application. Evaluation can be done after the completion of the teaching and learning process based on the effectiveness or strength of the android application as well as the student's achievement according to the ability level after using the android application. After the end of the teaching and learning process, evaluation needs to be done to see the strengths and weaknesses as well as the overall effectiveness of this android application so that improvements can be carried out so that the use of this android application can be implemented as much as possible in learning. In this phase, six (6) expert evaluators within primary school science teachers, multimedia experts that have extensive knowledge and experience in their field of study, and three students as a user to figure out their acceptance of the android application. At this stage, the usability of this android application will be evaluated through a questionnaire to elicit feedback on the usefulness and improvement of the android application. The evaluation and review phase aims to assess whether the android application meets the learning content and can support the teaching and learning process. Checklist forms are given to experts to test functionality in terms of content, interaction and interface design, and presentation of multimedia elements. After getting feedback from the experts, the developers will improve the android application based on the experts' comments.

3. Result and Discussion

This part discusses the process of analysis that has been carried out to discover all of the information about the android application produced in detail as well as the study findings obtained through the process of receiving responses from a checklist form. This evaluation is carried out to find out the acceptance of the Moon phases android application for standard 5 primary school students in supporting their learning process and to determine the functionality of the android application through the aspects of content, interaction, and interface design based on the testing and evaluation process. The results of the feedback will be presented in an understandable format through a frequency table value representation.

3.1 Students' Acceptance of the Moon phases Android Application

The user evaluation has been done to find out the acceptance level of the target users for this android application. Thus, in ASSURE model, it involves the process of testing the effectiveness of the android application to students who use it which were standard 5 primary school students that involve in science subjects. Table 5 shows the students' demographic.

Table 5
Students' demographics

Details	Gender	Race
Student 1	Male	Malay
Student 2	Female	Malay
Student 3	Female	Malay

Next, the process involves user evaluation based on the student's acceptance checklist form. This user acceptance analysis was done by standard 5 primary school students. The main purpose of this user analysis evaluation is to find out the user's acceptance of the android application in helping them

to understand the content and information presented. This user acceptance checklist contains 8 items and has been analyzed using frequency and percentage values. Table 6 shows the results of the students' acceptance analysis that has been done.

Table 6
Students' acceptance of the Moon phases android application

No.	Item	Frequency		Percentages
		Yes	No	(%)
1.	I love mobile learning	3	0	100
2.	I can study flexibly	3	0	100
3.	I was able to repeat the learning topics I had learned	3	0	100
4.	I was able to repeat answering practice questions	3	0	100
5.	I am interested in the graphics used	3	0	100
6.	I was interested in the animated video used	3	0	100
7.	I am interested in the audio used	3	0	100
8.	I can understand learning better	3	0	100
	Total average			100

As a result of the analysis of the student's acceptance of the moon phases android application, it can be concluded that their acceptance of the android application in supporting their learning process is positive. Criollo-C *et al.,* [33] state that students are nowadays more focused on interactive learning techniques, especially on mobile learning. The use of appropriate learning mediums can have an impact on student acceptance as well as increase student motivation in the learning process. All three students agreed that they were able to repeat the learning topics and exercises that they have learned. Thus, through the android application, students can explore learning independently according to their ability. This statement is supported by Hao *et al.,* [34] who state that students are more flexible in the process of learning and exploring experiences on their own. Next, all three users also agreed that the multimedia elements used on the android application were interesting. The use of multimedia elements in students learning process can stimulate memory and help facilitate their understanding. This is supported by the study of Jalinus [35] that stated the topic of learning based on the use of multimedia elements can be easily accepted by students. Therefore, there is no doubt that this learning style based on the use of mobile technology has transformed the country's education system which is in line with the changes of the globalization era.

3.2 Content Expert Acceptance Towards the Moon Phases Android Application

There are three (3) content experts that respond to the expert checklist forms. This content design analysis has been done by primary school science teachers. The main purpose of the content design analysis evaluation is to ensure that the target users can understand the content and information presented. Table 7 shows the content expert demographics.

Table 7
Content expert demographics

Details	Gender	Race	Education	Work experience	Jobs	Field of specialization
Content expert 1	Female	Malay	Degree	23 years	Teacher	Science
Content expert 2	Male	Malay	Master	16 years	Teacher	Science
Content expert 3	Female	Malay	Degree	20 years	Teacher	Science and Islamic study

Next, this section involves content experts' views based on expert checklist forms on the moon phases android application. This content design analysis is done by three (3) Science Year 5 elementary school teachers. This content design checklist contains 10 items for experts and has been analyzed using frequency values. Table 8 shows the results of the content design analysis that has been performed.

Table 8
Experts' content acceptance of the Moon phases android application

No.	Item	Frequency		Percentages (%)
		Yes	No	
1.	The content of this android application is easy to understand	3	0	100
2.	The content complies with the syllabus from the Ministry of Education Malaysia	3	0	100
3.	The language of the content delivery used through this android application is easy to understand	3	0	100
4.	The animation used through this android application is easy to understand	3	0	100
5.	The content of this android application can add to students' knowledge	3	0	100
6.	The content of this android application was well organized	3	0	100
7.	The content of this android application is following the learning needs of standard 5 primary school students	3	0	100
8.	The practice questions provided through this android application have helped to improve students' understanding	3	0	100
9.	The practice questions provided through this android application have helped to measure students' comprehension	3	0	100
10.	The user guide through this android application has helped users in exploring the android application	3	0	100
	Total average			100

As a result, all three (3) content experts agreed on the first item that the content of this android application can be easily understood by the users. Next, on the second item, all three (3) experts also agreed that the content is in line with the syllabus from the Ministry of Education Malaysia. In fact, according to Vlachopoulos and Makri [36], the arrangement of content in an orderly manner requires credibility and professional teaching knowledge. For the third and fourth items, all three (3) experts agreed that the language of the content delivery and animation of this android application is easy to understand. Productive and user-friendly android applications need to combine all three designs such as multimedia element presentation, content design, and interaction design as a creative and structured android application display [37]. As for the fifth item, all three (3) experts agreed that the content in this android application can increase students' knowledge. All three experts also agreed on the sixth item that the content in this android application is well organized. Next, for the seventh item, all three (3) experts also agreed that the content provided in this android application is following the learning needs of standard 5 primary school students that measure students' comprehension. Finally, all three experts (3) agree that the user guide helps users in exploring the android application. Content knowledge refers to the amount and organization of knowledge that is in the mind of a teacher or instructor, that is the amount of something that needs to be learned actually [38]. Educators must know and understand the facts, concepts, principles, theories, and procedures in the subject they are assigned to teach especially when they were using any android application. Teachers and instructors who do not have this understanding can give a wrong picture of the subject to their students.

3.3 Interaction and Interface Expert Acceptance Towards the Moon Phases Android Application

The interaction and interface evaluation for the moon phases android application involves three (3) experts that respond on the expert checklist forms. They were lecturers from higher educational institutions who have extensive knowledge and experience in the multimedia design field. Table 9 shows the demographics of a multimedia expert.

Table 9
Interaction and interface expert demographics

Details	Gender	Race	Education	Work Experience	Jobs	Field of specialization
Expert 1	Female	Malay	PhD	4 years	Lecturer	Educational Technology
Expert 2	Female	Malay	PhD	15 years	Lecturer	Information Technology and Multimedia
Expert 3	Female	Malay	PhD	17 years	Lecturer	Instructional Design

Next, the interaction design expert evaluation checklist contains 7 items built to test the level of functionality of this android application. The main purpose of the interaction design analysis evaluation process was to evaluate the functionality and suitability of the interaction link available in the android application. This interaction design checklist has been filled out by the experts and analyzed using frequency values. Table 10 shows the results of the interaction design analysis that has been performed.

Table 10
Experts' acceptance of the interaction design of Moon phases android application

No.	Item	Frequency		Percentages (%)	
		Yes	No	Yes	No
1.	The navigation link provided through this android application can be used properly without any errors	3	0	100	-
2.	The navigation link provided through this android application leads to the correct display page	3	0	100	-
3.	The function of the navigation icon provided through this android application is easy to understand	2	1	67	33
4.	The position of the navigation link provided through this android application was consistent on each display page	3	0	100	-
5.	The answer option link on the practice questions page provided through this android application work well	3	0	100	-
6.	Correct or incorrect feedback have been displayed after the user answers practice questions through this android application	3	0	100	-
7.	The total score has been displayed after the user answers practice questions through this android application	3	0	100	-
	Total average			95	5

As a result, the interaction design analysis from all three (3) experts agreed on the first item that the navigation link provided through this android application can be used properly without any errors. On the second item, all three (3) experts also agreed that the navigation link provided through this android application led to the correct display page. However, on the third item, only two (2)

experts agreed that the function of the navigation icon provided through this android application is easy to understand. Then, on the fourth item, all three (3) experts agreed that the position of the navigation link provided through this android application was consistent on each display page. As such, interaction design allows users to communicate and interact with products or android applications which need to have a display and menu that is simple and easy for users to use [39]. On the fifth and sixth items, all three (3) experts agreed that the position of the navigation link provided was consistent on each display page and correct or incorrect feedback have been displayed after the user answers practice questions through this android application. Siyam and Abdallah [40] state that each multimedia display requires a navigation link that allows users to control the android application according to their needs and it makes the product more user-friendly. Finally, all three experts agreed that the total score has been displayed after the user answers practice questions through this android application. Interaction design is an important aspect that needs to be considered when developing a product or android application. An attractive and easy-to-use design will make the user comfortable and happy to use the product or system [41].

Next, the expert assessment of the interface design contains 13 items that have been constructed as a checklist. The main purpose of the interface design evaluation process is to evaluate whether the interface design through the android application was suitable for the user. This interface design checklist also has been filled by the experts and analyzed using frequency values. Table 11 shows the results of the analysis of the interface design and multimedia presentation elements that have been performed.

Table 11
Experts' acceptance of the interface design of Moon phases android application

No.	Item	Frequency		Percentages (%)	
		Yes	No	Yes	No
1.	The interface design of this android application is interesting	3	0	100	-
2.	The design of the navigation link used on the display page through this android application was suitable	3	0	100	-
3.	The background design of the android application suitable for the target user	3	0	100	-
4.	The design of the navigation link through this android application is suitable	2	1	67	33
5.	The position of the navigation link through this android application is suitable	3	0	100	-
6.	The size of the navigation link through this android application is suitable	3	0	100	-
7.	The color of the navigation link through this android application is suitable	3	0	100	-
8.	The text size of the navigation link through this android application is suitable	3	0	100	-
9.	The type of text used through this android application is suitable	2	1	67	33
10.	The color of the text used on each display through this android application is suitable	3	0	100	-
11.	The animation used through this android application work well	3	0	100	-
12.	The practice questions displayed on the exercise page through this android application were well organized	3	0	100	-
13.	The background music of the android application suitable for the target user	2	1	67	33
	Total average			92	8

As a result, the interface design and the multimedia presentation element analysis from all three (3) experts agreed on the first item that the interface design through this android application is interesting. Miraz *et al.,* [42] state that user interface design is the most important and critical part of a learning product because learning effectiveness and interface design are well-related and interdependent with each other. On the second item, all three (3) experts agreed that the design of the navigation link used on the display page through this android application was suitable. Next, all three (3) experts also agreed on the third item on the background design of the android application suitable for the target user. However, on the fourth item, only two (2) experts agreed that the design of the navigation link through this android application is suitable. On the fifth and sixth items, all three (3) experts agreed that the position and size of the navigation link through this android application are suitable.

Then, all three (3) experts agreed on the seventh item that the color of the navigation link through this android application is suitable. Furthermore, for item eight, all three (3) experts agreed that the text size of the navigation link through this android application is suitable while for the ninth item only two (2) experts agreed that the type of text used through this android application is suitable. Next, on the tenth and eleventh item, all three (3) experts agreed that the color of the text used on each display through this android application is suitable and the animation used through this android application work well. Besides, good color selection is also related to aspects of human psychology because color plays a role in influencing human perception [43]. The use of inappropriate colors can cause users to give a variety of different reactions and feelings that can affect student engagement. Finally, only two (2) expert agrees that the background music of the android application is suitable for the target user. As such, the importance of user interface design is to facilitate and smoothen the learning process, to understand the navigation flow of the program, and also lead an independent navigation style to support content and messages [44].

This android application has been developed based on the ASSURE model as a guide in the implementation of the product development process. The developers chose the ASSURE model introduced by Heinich *et al.,* [29]. This instructional design model is used to plan the systematic use of media as the model can assist educators in planning learning that utilizes the use of media in the teaching and learning process. According to Adi *et al.,* [45], the ASSURE model is a learning model that involves students optimally as they learn to use the information to solve problems and they implement it by interacting with teachers, peers, media, and resources materials. All elements in the ASSURE model are interrelated and must be given attention by the teacher to plan the lesson so that the main goal expected from the lesson will be achieved. Besides, through the foundational knowledge element based on the 21st-century learning model, the students will be trained to have skills that can be used in the future, such as good communication skills, and the ability to collaborate and solve problems based on the reality of life [28]. As such, the ASSURE learning model integrated foundational knowledge element based on the 21st-century learning model consists of core content knowledge; digital/ICT literacy and cross-disciplinary knowledge in this android application tend to make it easier for students to accept, making it easier for teachers to deliver information and materials while involving students in learning activities.

The main purpose of the emergence of an interactive learning android application is based on the rapidly changing progress of information technology. Therefore, the education system also needs to undergo a revolution to move along with this progress. Among the importance of this android application is that it can encourage students to increase their motivation and interest in science subjects, allow students to learn independently and develop according to their ability and interest level and facilitate the teaching and learning process, where students can use the advantages of the android application to perform demonstrations in class, even without complete equipment.

4. Conclusions

The results of the study showed that all experts agree that the content of this android application is easy to understand, the content this android application is suitable for the student's learning needs and the topic description is animated in an interesting way that is also suitable for the use by the targeted users. As such, this android application seems to be useful as one of the teaching aids for science subjects in attracting students' interest, especially in the moon phases topic and is expected to provide a positive impact in terms of functionality and usability of android application in the present and also in the future. The development of this android application has been evaluated by students and experts and it can be used as a guide to help improve students' understanding during the teaching and learning process. In addition, the outcome of this study hopefully will help the student to create knowledge continuously in their learning process so that they can learn independently.

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