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# Development and Usability of 'Skeletopedia' Mobile Application for Human Skeletal System

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## Abstract

This study aimed to develop an android-based mobile learning application, Skeletopedia based on the cognitive constructivism and cognitive theory of multimedia learning and evaluated its usability as an educational tool for Form Five Biology students. The Skeletopedia was developed according to ADDIE model. It was designed to aid the Form 5 students in understanding and remembering the Latin terminology of human skeletal system as well as allowing them to visualise the human skeleton through three-dimensional augmented reality skeletal models. Two biology teachers were appointed to assess the face and content validity of the questionnaire and Skeletopedia, while 97 Form Five Biology students from Mara Junior Science College (MJSC) FELDA Trolak were selected as respondents for the field study. The usability questionnaire developed in this study had obtained high validity ($\kappa$ = 1.00, CVI = 1.00) and reliability (Cronbach's Alpha Coefficient = 0.970). The 'Skeletopedia' application had acquired high validity in terms of face validity ($\kappa$ = 1.00) and content validity (CVI = 1.00). The findings show that perception of students on the design of the Skeletopedia have a mean score of 3.637 (SD = 0.443), the mean score for the content is 3.598 (SD = 0.444), the efficiency (mean = 3.650, SD = 0.434), and usefulness (mean = 3.652, SD = 0.430). In conclusion, Skeletopedia has a high content validity and reliability value. Students' perception of the Skeletopedia also has a high mean value. The findings of this study implied that the Skeletopedia is appropriate and effective to be used as a self-learning tool ubiquitously in enhancing students' understanding of human skeletal system without time and space constraints due to its portability and flexibility.

**Keywords:** Human Skeletal System, Mobile Learning, Usability Evaluation

## INTRODUCTION

Biology is an aspect of science and technology that makes a significant contribution to the development of society and the improvement of a country in a variety of ways [1]. However, many studies have revealed about the challenges encountered by the students in learning this subject. Jayawardana [2] reported that students are passive and less interested in learning biology due to content-heavy curriculum. In addition, biological phenomena are not visible to naked eyes, the concepts are too abstract, and there are a large number of foreign/Latin terms [3]. Many students find the human skeletal system to be a challenging topic to understand [4]. Instead of that, the organ structures and functions in Latin are difficult to remember, dissection practical is often carried out through didactic lectures, and students lack of visual understanding in learning anatomy [4, 5]. Various studies have been carried out to aid the students' in learning human skeletal system. However, studies have not been carried out to explore about the multimedia-based mobile learning application in line with the Curriculum and Assessment Standards Document (*DSKP*) –

formulated content standards and learning standards for the Standard Secondary School Curriculum (*KSSM*).

In this digital era, a new paradigm should be created for biology learning. It is time to make full use of the advancement of technology as a means of biology learning by e-learning through the use mobile learning applications. The use of mobile devices is required in mobile learning to improve learning and academic performance by allowing students to learn remotely at any time and in the comfort of their own homes [6]. Mobile learning enhances the learners' need-satisfaction, autonomous motivation, and behavioural intentions [7]. Similarly, Bernacki et al. also reported that mobile technologies can be used to enhance the learners' learning processes and understanding [8]. Thus, to avoid the passive and boring learning session due to above-mentioned challenges, a collaborative learning technique or games that stimulate several aspects of biology education seem to be a viable tool.

Cognitive constructivism learning theory and cognitive theory of multimedia learning are being embedded in the study. Teachers act as the facilitator to further enhance students' cognitive level through critical exploration and discovery learning by using the 'Skeletopedia' application. The students are allowed to carry out ubiquitous self-paced learning about the topic of human skeletal system without any time and space constraints. They get to gain new knowledge through the content prepared while integrating their prior knowledge regarding the topic when they are involved actively in the learning process. After exploring the topic, the users can answer the formative assessments by applying the knowledge and information which are obtained previously. Teachers are only acting as the observer, planner and facilitator in assisting the students to increase their understanding, comprehension, and interest in learning about the human skeletal system. On the other hand, the content of the 'Skeletopedia' application is carefully selected to aid students' learning process, following the underlying cognitive theory of multimedia learning. Only relevant learning materials such as virtual 3D skeleton model, songs, bite-sized notes, videos, podcasts, labelling diagrams activities and short quizzes are inserted into the application to avoid burdening the students with information, while maximising the effectiveness of the students' learning process. Various graphics and animated videos are designed together with understandable, short and precise notes in helping the students to incorporate relevant information into their working memory. Meanwhile, the learners can also engage actively with the learning material by flipping around the virtual 3D skeleton model to learn about the topic of human skeletal system. The visual information and auditory information processed will be further created into a mental representation which is effective in aiding the retention of the key information of the learning topic in their long-term memory.

In this scenario, two objectives were aimed for this study: (1) to develop a mobile application 'Skeletopedia' as a support tool for the teaching and learning of human skeletal system, and (2) to determine the usability of the developed 'Skeletopedia' among Form Five Biology student. The following research questions were addressed in this study: (i) is the developed mobile application 'Skeletopedia' has satisfactory face and content validity? (ii) is the developed mobile application 'Skeletopedia' has satisfactory usability?

## METHODOLOGY

This is a developmental research. ADDIE model was chosen as the instructional design model for the development of the innovative educational product, 'Skeletopedia' application in this research. ADDIE model contains 5 phases, including analysis, design, development, implementation, and evaluation.

Analysis phase is the basis for all phases of an instructional design [9]. A needs analysis was conducted by selecting 144 students randomly among 230 Form Four Biology students from MARA Junior Science College (MJSC) Taiping, Perak with the use of 'Picker Wheel' to determine on whether the difficulties and challenges of learning human skeletal system in Form Four Biology were relevant (unpublished data). Besides that, the drawbacks of existing teaching and learning tools built for the

subtopic of human skeletal system were also been investigated. The research objectives and questions of this study were formulated at this stage. The Form Five Biology students from MJSC FELDA (Trolak), Sungkai, Perak were chosen as the research sample through random sampling technique.

Secondly, design phase is referred to the process of converting analysis data into understandable, feasible steps by establishing preliminary plans for the educational product [9]. The road map was constructed to direct the researcher in developing solutions to the issues. A mobile application, known as Skeletopedia' with innovative, creative, and interactive features like three-dimensional augmented reality skeletal models, labelling diagrams and quizzes, visual learning materials like graphics and animated videos, audio learning material like podcasts and songs for the subtopic of human skeletal system in Form Four Biology was designed. The findings had shown that the 'Skeletopedia' application is able to resolve the difficulties and challenges in learning human skeletal system, which includes Latin terminologies are difficult to understand, complicated and detailed information is difficult to memorise, conventional 'chalk-and-talk' teaching method is too boring, and abstract concept is difficult to be visualised. The Curriculum and Assessment Standards Document (*DSKP*) – formulated content standards and learning standards for the Standard Secondary School Curriculum (*KSSM*) were examined in order to be incorporated into the conceptual framework for the creation of the mobile learning application. Cognitive constructivism learning theory and cognitive theory of multimedia learning were chosen as the underlying learning theories to guide the research. Then, specific learning objectives were established and aligned with the syllabus. The layouts and interfaces of the 'Skeletopedia' application were designed by the researcher with the use of Microsoft PowerPoint software as shown in Figure 1. The 'Skeletopedia' application was designed with six sections, including the three-dimensional augmented reality skeletal models, songs with terminological lyrics, short notes with graphics, short learning videos with animations, short podcasts, and interesting formative assessments like labelling diagram and quizzes.

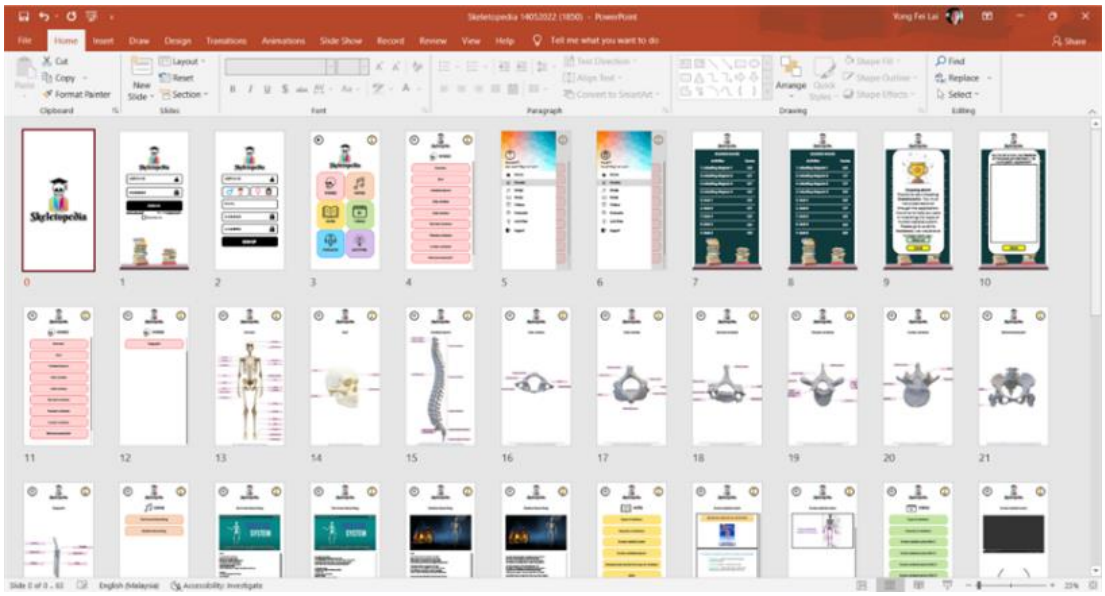

**Figure 1** Design of layouts and interfaces of the 'Skeletopedia' application on Microsoft PowerPoint

Thirdly, the development phase involves transforming the design of the prototype into a functional product [9]. Relevant graphics, pictures, videos and animations were selected by the researcher to develop the learning materials. The three-dimensional skeletal models were edited and labelled by using Paint 3D application. Microsoft PowerPoint software was used to create and design the short notes, slides of the learning videos, and the formative assessments. The songs, short learning videos, and short podcasts were created by using Wondershare Filmora X video editing software. Then, all of the learning materials created for the six sections as planned in the design phase were combined using Android Studio software to build a functional 'Skeletopedia' application as presented in Figure 2. The directory map of the 'Skeletopedia' application was depicted in Figure 3. The questionnaire was also developed in this stage with the items adapted and modified from Lund [10]; Soad et al. [11]; Oyelere et al. [12]; Kuhnel et

al. [13]. The questionnaire was built to evaluate the perceptions of the respondents towards the usability level of the 'Skeletopedia' application in terms of design, content, efficiency, and usefulness.

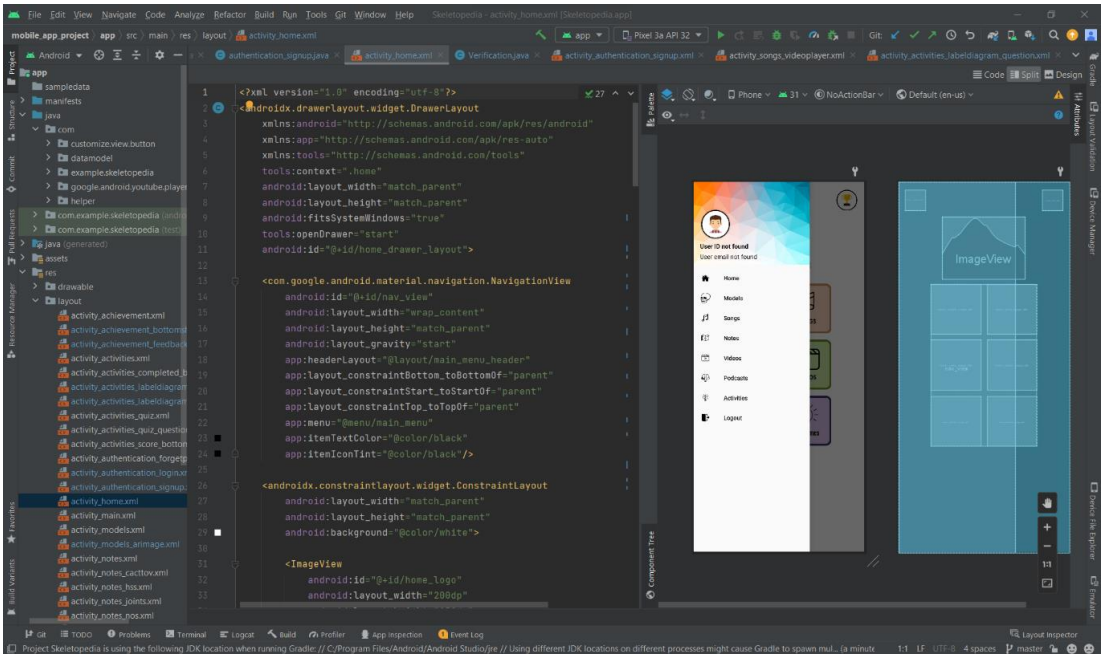

**Figure 2** Learning materials combined with the appropriate interfaces in developing the 'Skeletopedia' application on Android Studio

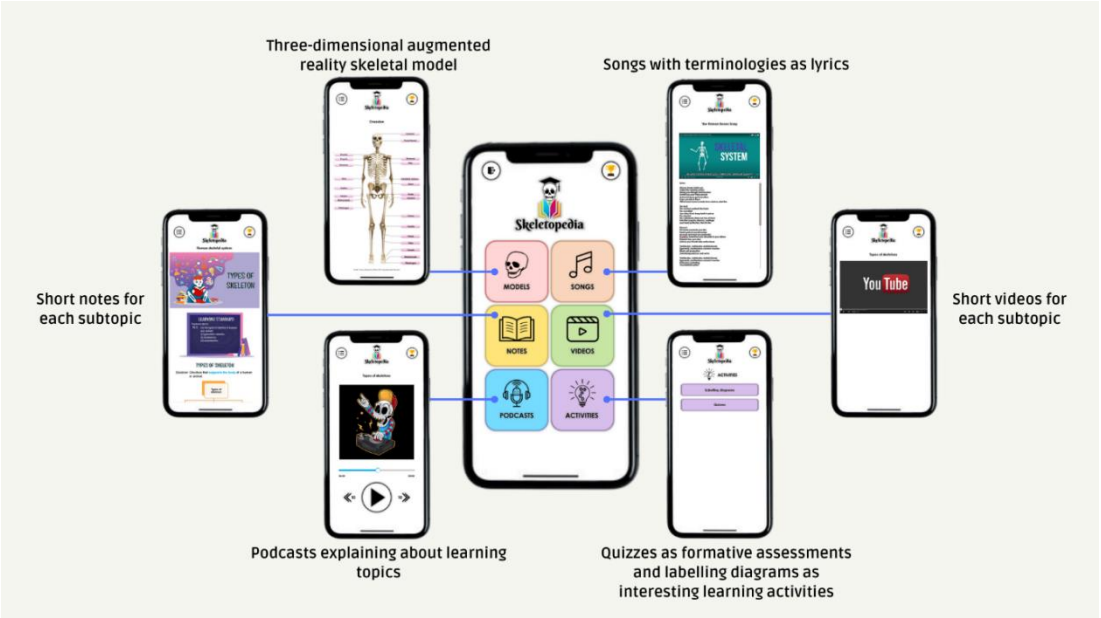


**Figure 3** Directory map of 'Skeletopedia' application

Followed by the fourth phase, the implementation phase involves using the product in a practical setting, or, to put it another way, executing the solution in an educational environment. This implementation process may be carried out experimentally on a group of professionals in the field before adopting the procedure widely in the community [9]. In this study, the validity studies of the questionnaire and the 'Skeletopedia' application in terms of face and content validity were evaluated by two Biology

teachers from Sekolah Menengah Jenis Kebangsaan (SMJK) Hua Lian, Taiping, Perak as the panel of experts. The validity study of the research instrument and product were analysed using the Cohen's Kappa coefficient (κ) suggested by Cohen [14] and Content Validity Index (CVI) proposed by Lynn [15]. Pilot study was conducted among 30 Form Five Biology students from MJSC FELDA (Trolak), Sungkai, Perak to measure the reliability of the developed questionnaire. According to Johanson and Brooks [16], a fair minimum criterion for pilot study is 30 representative respondents from the population of interest. The outcomes were analysed through the value of Cronbach's Alpha coefficient. The sample size was determined based on the table of determining samples for a finite population as suggested by Krejcie and Morgan [17]. The field testing was conducted among 97 students from 130 Form Five Biology students from MJSC FELDA (Trolak), Sungkai, Perak selected randomly, excluding the 30 respondents who participated in the pilot study to evaluate the usability level of the 'Skeletopedia' application in terms of design, content, efficiency, and usefulness through four-points Likert scale. The use of four-points Likert scale to evaluate the items of the questionnaire in this study can help to prevent the likelihood of the midpoint being used inappropriately and to give clearer interpretations. There is a likelihood for the respondents to choose the midpoint when they are unable to evaluate the items effectively based on their opinions, hence the midpoint is eliminated in the study to fulfil the objectives of the study as the four-point Likert scale is used to facilitate the collection of data more accurately.

Lastly, the final phase of ADDIE model is the evaluation phase. Form Five Biology students were gathered in a hall, and they were introduced to the Skeletopedia. Students were given the QR code to download the mobile app. The respondents were briefed about how to use the Skeletopedia. All respondents were given one week to explore the Skeletopedia before answering the questionnaire. The collected data were analyzed using descriptive analysis, by determining the frequency, mean and standard deviation. The interpretation of mean score level was as follows: low (1.00-2.00), moderate (2.00-3.00), and high (3.01-4.00) (Talib, 1996) [18].

## RESULTS AND DISCUSSION

### Validity and reliability

The usability questionnaire and 'Skeletopedia' application developed in this study had obtained high validity (κ = 1.00, CVI = 1.00) and reliability (Cronbach's Alpha coefficient = 0.970). Cohen's kappa coefficient above 0.90 is interpreted as almost perfect for the level of agreement [19]. No review and suggestions for improvement were suggested by the experts. Warrens claimed that there is a perfect agreement between the raters if Kappa value of 1 is obtained [20]. A research instrument with an index of 0.80 or higher is judged as relevant and appropriate [21]. Alpha values above 0.9 indicate excellent and exceptional internal consistency [22].

### Perceptions towards the usability level of the 'Skeletopedia' application

The perception of Form Five Biology students on the 'Skeletopedia' was analysed based on design, content, efficiency and usefulness aspects. The average mean score values obtained for the usability level of the 'Skeletopedia' application was shown in Table 1.

**Table 1** Descriptive evaluation of 'Skeletopedia'

| No. | Items | Mean Score Value | Standard Deviation | Value Interpretation |
|---|---|---|---|---|
| **Design** | | | | |
| 1 | The font size and font style used are appropriate, suitable, and easy to read. | 3.64 | 0.483 | High |
| 2 | The format or layout of 'Skeletopedia' is constructed in a | 3.62 | 0.488 | High |

| | | | | |
|---|---|---|---|---|
| | well-organised and logical manner. | | | |
| 3 | The colour used in the interfaces and layout of 'Skeletopedia' is suitable, appropriate, and attractive. | 3.64 | 0.483 | High |
| 4 | The design of 'Skeletopedia' is interesting and appealing as a mobile learning application. | 3.65 | 0.480 | High |
| | **Average** | **3.64** | **0.44** | **High** |
| **Content** | | | | |
| 5 | The instructions provided in 'Skeletopedia' are clear, concise, and easy to follow. | 3.62 | 0.488 | High |
| 6 | The learning materials contained in 'Skeletopedia' allow me to understand, remember and memorise the terminology for the topic of human skeletal system easily. | 3.55 | 0.500 | High |
| 7 | The learning materials contained in 'Skeletopedia' have discussed the subtopics of human skeletal system with relevant illustrative examples are helpful in visualising the abstract concept. | 3.64 | 0.483 | High |
| 8 | The level of difficulty of the activities contained in 'Skeletopedia' is relevant to the syllabus of human skeletal system which is in line with the Curriculum and Assessment Standards Document (*DSKP*). | 3.59 | 0.495 | High |
| | **Average** | **3.60** | **0.44** | **High** |
| **Efficiency** | | | | |
| 9 | The interactive features of the mobile learning application, 'Skeletopedia' are effective for learning the topic of human skeletal system. | 3.69 | 0.465 | High |
| 10 | The mobile learning application, 'Skeletopedia' made the learning environment fun and interesting. | 3.65 | 0.480 | High |
| 11 | The mobile learning application, 'Skeletopedia' allows me to carry out self-determined learning ubiquitously without time and space constraints due to its portability and flexibility. | 3.64 | 0.483 | High |
| 12 | The learning materials contained in 'Skeletopedia' allow me to understand and master the topic of human skeletal system. | 3.62 | 0.488 | High |

| | | | | |
|---|---|---|---|---|
| 13 | The mobile learning application, 'Skeletopedia' allows me to participate actively in the learning process. | 3.65 | 0.480 | High |
| | **Average** | **3.65** | **0.43** | **High** |
| **Usefulness** | | | | |
| 14 | The mobile learning application, 'Skeletopedia' is well-designed and user-friendly. | 3.67 | 0.473 | High |
| 15 | The design and layout of the mobile learning application, 'Skeletopedia' are dummy proof and extremely easy to operate. | 3.65 | 0.480 | High |
| 16 | The mobile learning application, 'Skeletopedia' can be accessed through any Android based devices anytime and anywhere. | 3.61 | 0.491 | High |
| 17 | The mobile learning application, 'Skeletopedia' is efficient and effective to enhance and comprehend understanding for the topic of human skeletal system. | 3.65 | 0.480 | High |
| 18 | The mobile learning application, 'Skeletopedia' is suitable to be used as a self-learning tool for the topic of human skeletal system. | 3.68 | 0.469 | High |
| | **Average** | **3.65** | **0.43** | **High** |
| | **Overall Average** | 3.636 | 0.413 | High |

The average mean score values obtained for the constructs of design was high (3.64). This result can be supported by the findings of Peters [23] and Kamaruddin [24], saying that the design element of educational software development is critical in ensuring the software's greatest efficacy in assisting the teaching and learning process. The learning environment is made easy yet exciting with the use of images in a variety of shapes and colours as well as non-boring font styles [25]. The layouts of the 'Skeletopedia' application were designed with interesting icons and attractive colours to stimulate the students' interest and improve their learning experiences. According to Siong and Osman [26], students' motivational factor will be influenced if the learning materials created have intuitive and interesting interfaces. This allows them to enjoy the learning process while increasing their eagerness to participate in the lessons.

Besides, the average mean score values obtained for the constructs of content was high (3.60). This finding reflects those of Yusuf [27] who claimed that the content of a developed software must be adhered to the curricula in order to be used as a learning aid. Furthermore, a more focused and structured learning process is conducted by using learning materials which are aligned with the learning objectives of the topic [28]. The learning materials of 'Skeletopedia' application were relevant to the syllabus of human skeletal system which is in line with the Curriculum and Assessment Standards Document (DSKP). Various illustrative examples such as graphics, animated videos, and three-dimensional augmented reality skeleton models were created to facilitate the students' learning process. As explained by Shabiralyani *et al*., visual aids such as models, pictures, videos and slides can provide direct experience to the students since students can understand or comprehend the lesson better [29]. Students who understand the learning topic can remember and memorise the terminologies related to the topic easier. Rusli et al. stated that

interactive multimedia which involves the five elements such as video, pictures, text, audio and animation can help students to understand the content of the lesson and re-explain the learning topic precisely [30]. The use of diverse multimedia can benefit the verbal and visual channels in our memory, which are excellent ways to aid in the process of obtaining, storing, and accessing knowledge during the learning process [31, 32].

In addition, the average mean score values obtained for the constructs of efficiency was high (3.65). These findings are in concordance with the findings of Kumar et al. who demonstrated a learning tool such as mobile devices have shown great possibilities in and out the classroom and have revolutionised the teachers' teaching method [33]. The use of smartphone application to carry out mobile learning allows students to better understand the learning concept [34]. In this study, the mobile learning application, 'Skeletopedia' made the learning environment fun and interesting, allowing the students to participate actively in the learning process and master the topic of human skeletal system expeditiously. This is supported by the research findings of Naismith et al [35], which claim that mobile learning applications ensure learner-centered, highly situated, personal, and collaborative learning. Furthermore, according to Gillespie, the incorporation of technology in education can increase learners' cooperation in completing learning tasks [36].

Apart from that, the average mean score values obtained for the constructs of usefulness was high (3.65). This finding is similar to Jeno et al. [7] study, which found that mobile learning has the potential to provide a variety of learning opportunities, including authentic learning by working on tasks related to the immediate learning goals, as well as situated learning, and context-aware learning. In the current study, 'Skeletopedia', a mobile learning application, was efficient and effective in improving and understanding of the human skeletal system. Furthermore, 'Skeletopedia' app was well-designed and user-friendly. According to Ahmad Fkrudin et al. [28], an educational application or software must be designed with interactive and user-friendly features that make use of multimedia to keep students from becoming bored. According to Doyle, the learning process involving the use of mobile applications is more productive and versatile for any topic, and it is extremely simple to be used to explain about the learning information [37].

The overall average mean score value acquired for the usability level of the 'Skeletopedia' application was 3.64, which was considered as high level of agreement. The respondents agreed to all the items for all four constructs. Thus, it can be concluded that the 'Skeletopedia' application was believed to have high usability level based on the perceptions of the Form Five Biology students.

## CONCLUSION

The 'Skeletopedia' application was successfully developed for the topic of human skeletal system in Form Four Biology following the five stages of ADDIE model. It can be acquired easily in Android system and is suitable as an educational resource in classroom teaching settings. The questionnaire and 'Skeletopedia' application developed had obtained high validity in terms of face and content validity. The findings of the evaluation on usability level of the 'Skeletopedia' application based on the perceptions of the Form Five Biology students indicated that the educational mobile application is efficient and appropriate to be used as a self-learning tool for the topic of human skeletal system. In addition, the inclusion of the 'Skeletopedia' application in classroom activities was designed to develop interest in the topic, thus enhancing in quick recall with retention of knowledge as compared with the conventional teaching. Thus, the positive implications of this study are able to provide insightful perspectives in developing a mobile learning application in the future study to generate engaging learning opportunities for students.

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