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SafeSteps: A Persuasive Child Pedestrian Safety Learning Mobile Application

Nadia Abdul Wahab[1*], Muhammad Aiman Azhar[2], Aznoora Osman[3], Norfiza Ibrahim[4], Azmi Abu Seman[5], Siti Sarah Md Ilyas[6]

[1,2,3,4,5,6]*College of Computing, Informatics, and Mathematics, Universiti Teknologi MARA Perlis Branch, Arau Campus, 02600 Arau, Perlis, Malaysia*

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ABSTRACT

This study focuses on the design, development, and evaluation of SafeSteps, a mobile application dedicated to child pedestrian safety. Employing multimedia elements, SafeSteps imparts knowledge on pedestrian safety to children, with an integrated quiz module enhancing learning activities. The project development adhered to the Waterfall Model Methodology, encompassing distinct stages of analysis, design, implementation, testing, and documentation. Guided by the principles of persuasive technology and multimedia, the application was developed using Android Studio as the Integrated Development Environment (IDE) tool. A User Experience Testing (UXT) involving 31 children aged six to twelve aimed to assess engagement, identify usability concerns, and discover areas for enhancement. Utilizing the User Experience Questionnaire (UEQ), the study gathered feedback, revealing a majority expressing a positive perception of SafeSteps in terms of attractiveness, efficiency, perspicuity, dependability, stimulation, and novelty. The UXT findings offer significant insights into user perceptions and interactions with SafeSteps. This information will be instrumental in identifying potential areas for improvement, implementing design modifications, and enhancing the overall user experience of the mobile application, emphasizing the importance of incorporating multimedia and interactive elements in child pedestrian safety interventions.

1. INTRODUCTION

A pedestrian refers to an individual who is engaged in the act of travelling by means of walking, typically along a designated pathway such as a sidewalk, crosswalk, or other demarcated area specifically intended for pedestrian use. They are frequently encountered in urban environments, cities, and residential

[1*] Corresponding author. *E-mail address*: nadiawahab@uitm.edu.my
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communities, where they engage in pedestrian travel to access their desired locations, engage in physical activity, or partake in recreational pursuits. Pedestrians are obligated to adhere to traffic regulations and signals, utilize designated crosswalks, and maintain situational awareness in order to safeguard their well-being and that of others (Obeng-Atuah et al., 2016).

Child pedestrians encompass a demographic of children who traverse on foot to and from educational institutions, engage in recreational pursuits, or partake in leisurely activities within residential zones. According to Deb (2019), adult pedestrians may exhibit higher levels of awareness, judgment, and traffic anticipation compared to their younger counterparts. The imparting of knowledge and skills pertaining to pedestrian safety to children is of paramount importance in facilitating their ability to navigate roads and streets securely. The significance of utilizing crosswalks, engaging in visual scanning in both directions before crossing the roadway, and adhering to traffic signals has been underscored in recent research conducted by Riaz et al. (2022).

Child pedestrian fatalities and injuries in Malaysia are a significant cause for concern, particularly in urban regions characterized by high volumes of vehicular traffic. According to a report by the Malaysian Institute of Road Safety Research (MIROS), a considerable proportion of road traffic fatalities in Malaysia can be attributed to pedestrian fatalities. Based on the findings of Toroyan (2015), the World Health Organization (WHO) has determined that child pedestrians, regardless of their age, face a significant likelihood of being involved in road traffic collisions. It has been observed that approximately 38% of children sustain injuries or lose their lives as pedestrians on roadways annually. According to a study conducted by Darus et al. (2018), in Malaysia, there were a total of 2,243 reported incidents of child-pedestrian casualties, involving individuals between the ages of 0 and 18, during the period of 2009 to 2012. These incidents accounted for approximately 27.9% of the overall number of pedestrian casualties. Consequently, this situation suggests that child pedestrians exhibit a heightened vulnerability to traffic-related injuries.

Child pedestrian accidents in Malaysia can be attributed to various factors. These include urbanization and high traffic density, inadequate pedestrian infrastructure, instances of speeding and reckless driving, as well as a lack of awareness and education among both children and adults regarding pedestrian safety practices and road regulations. These factors collectively contribute to the heightened vulnerability of child pedestrians (Darus et al., 2022). Children are disproportionately vulnerable to road traffic accidents as a result of their small physical stature and limited cognitive abilities (Cloutier et al., 2021). The high rate of involvement can be attributed to the concurrent growth and underdevelopment of their physical and cognitive aspects.

In addition to road safety campaigns and awareness programs, the utilization of mobile applications can serve as a valuable resource in delivering interactive and captivating methods for educating children on pedestrian safety. Educational materials may encompass quizzes, games, and simulations, which serve the purpose of facilitating children's comprehension and application of crucial safety principles. The utilization of animations, videos, and graphics within a mobile application could serve as an effective means to visually illustrate and exemplify safe pedestrian behaviours. The utilization of visual aids has the potential to enhance children's comprehension and retention of educational content.

2. LITERATURE REVIEW

Pedestrians constitute a demographic that faces a heightened vulnerability to vehicular collisions and involvement in road-related incidents (Hamidun et al., 2017). According to Solah et al. (2018), the prevalence of road accidents involving pedestrians in Malaysia is a matter of significant concern. A report by World Health Organization in 2023 reported that pedestrian fatalities constituted 22% of road accident

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cases globally, with certain countries reporting pedestrian involvement in two-thirds of all such incidents. The ASEAN countries of Myanmar, Philippines, and Singapore exhibited the highest incidence of pedestrian fatalities, surpassing 15% (Solah et al., 2018). Conversely, Malaysia, Thailand, Indonesia, Cambodia, Brunei, and Indonesia demonstrated rates ranging from 8% to 13% (Solah et al., 2018).

Children are at a heightened risk of being involved in road accidents as a result of their physical and cognitive limitations (Thurman, 2016). In Malaysia, during the period from 2007 to 2009, a total of 13% of child pedestrians aged 1 to 12 years old lost their lives as a result of road accidents (Kamarudin et al., 2020). According to Schwebel (2017), children with smaller body sizes may experience limitations in their visual perception and visibility to other individuals using the roadways. Child pedestrians are consistently exposed to hazards when commuting to and from educational institutions (Hamidun et al., 2017). The act of looking downward while crossing a road without the capacity to signal an approaching vehicle can potentially pose a hazard. In the study conducted by Hamidun et al. (2017), it was found that child pedestrians tend to underestimate the speed of vehicles and the amount of time necessary to safely cross the road.

To effectively promote pedestrian safety, it is imperative to possess a comprehensive understanding of the various factors contributing to pedestrian collisions. These factors encompass not only pedestrian behaviour, but also encompass location type, road type, and light condition. Based on the findings of a study conducted by Solah et al. (2018), it was determined that the majority of pedestrian accidents, specifically 55%, transpire in rural areas. Additionally, 27.7% of these accidents were observed to transpire in urban areas, while the remaining incidents occurred in built-up areas (Solah et al., 2018).

Various factors have been identified as potential contributors to road traffic accidents in rural areas. These factors include inadequate road maintenance, substandard public transportation services, limited knowledge of traffic regulations, higher vehicle speeds, insufficient provision of segregated pedestrian facilities, and restricted availability of medical emergency services (Staton et al., 2016). Efficient strategies ought to be implemented to mitigate this issue. Consequently, it is crucial to create a mobile application that imparts knowledge and raises awareness among young pedestrians.

Persuasion technology can be defined as an interactive computer system that is specifically designed to exert influence over individuals' opinions or behaviours. The act of persuasion necessitates a voluntary alteration in conduct, convictions, or both (Fogg, 2003). Consequently, it is postulated that the utilization of interactive technology will facilitate the persuasive endeavour. Numerous scholars have endeavoured to create Persuasive Technology with the aim of aiding individuals in modifying their lifestyles and fostering increased physical activity (Aldenaini et al., 2020). Persuasive Technology interventions targeting sedentary behaviour that poses a threat to overall safety. In his seminal work, Fogg (2003) delineated a comprehensive set of 42 principles pertaining to Persuasive Technology. These principles serve as a valuable resource for effectively influencing individuals' cognitive processes, applicable across various domains including both commercial and non-commercial contexts (Aldenaini et al., 2020).

Fig. 1 depicts the area where computing technology and persuasion intersect. This discipline is rapidly evolving in order to change how people think and act contexts (Rosmani & Wahab, 2011). This trend is likely to continue, especially as mobile apps become more accessible.

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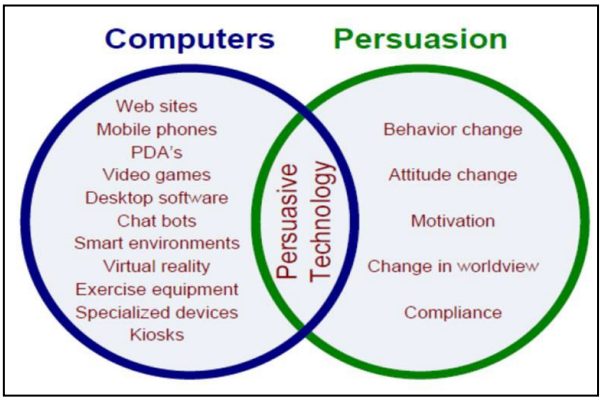

Fig. 1. Persusive Technology

From the literature search, it was discovered that mobile applications can potentially improve understanding and awareness among young pedestrians about pedestrian safety. It was also observed that mobile applications with multimedia and persuasive elements are suitable for use as a medium to provide children with knowledge and understanding about road safety.

3. METHODOLOGY

This study utilized the Software Development Life Cycle (SDLC) with the Waterfall Model to ensure that each phase of the study could be managed effectively and efficiently. The waterfall model shown in Fig. 2 is composed of five stages: analysis, design, implementation, testing, and documentation.

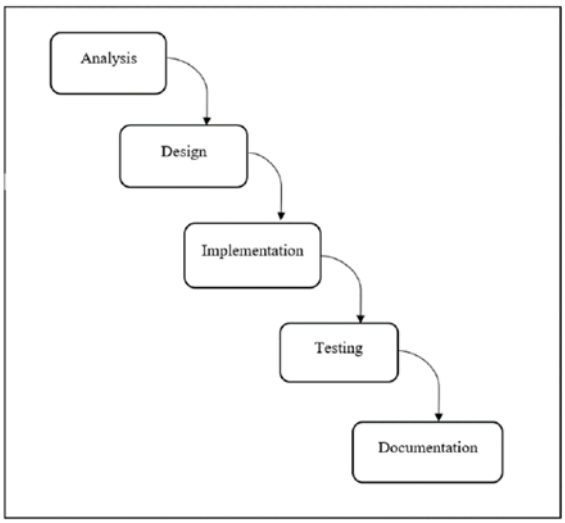

Fig. 2. Waterfall Model

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3.1 Analysis

All possible requirements of the system to be developed are captured in this phase and documented. Several activities were carried out by the researcher during this phase to determine the project title, review related studies, and identify appropriate research methodology for this study. This phase resulted in the completion of the project proposal.

3.2 Design

The requirement specifications from the first phase are studied in this phase and the system design is prepared. This system design helps in specifying hardware and system requirements and helps in defining the overall system architecture. During this phase, the activities that were carried out were designing the Data Flow Diagram, Entity Relationship Diagram and User Interface Design.

3.3 Implementation

With inputs from the design phase, the mobile application is first developed in small, integrated modules. Each module is developed and tested for its functionality. In this phase, the researcher has completed several activities such as the creation of learning videos, development of user interfaces, creation of the source code and improvement of the application.

3.4 Testing

In this phase, the researcher has performed several types of testing such as functionality and user experience tests to evaluate the application. The entire modules within this mobile application are tested during Functionality Testing for faults and failures. User Experience Testing (UXT) was utilized to evaluate various aspects of user experience to determine the best way for the application and its elements to interact with its audience. The study involved thirty-one (31) participants, all of whom were school-aged children.

3.5 Documentation

Documentation encompasses a wide range of materials, spanning from explanatory comments within the code to comprehensive user manuals. Effective documentation can contribute to the process of learning from errors, thereby preventing their recurrence. During this phase, the researcher has completed the project report based on the research conducted.

4. CONSTRUCTION

This section will discuss the construction details of this study. It comprises the software requirements and the details about each module within SafeSteps. This section also will detail the discussion on how multimedia elements are being utilized and Persuasive Technology Principles are being integrated into the user interface design.

4.1 Software Requirements

The successful completion of system development depends on the employment of proper software. Android Studio is the project's primary piece of software. Users may create apps in a unified ecosystem for Android Wear, Android TV, Android Auto, Android phones, and Android tablets. Animaker is a cloud-based DIY animated film creation tool that has features built in to meet the growing demand for animated video creation. With a strong emphasis on studio standards, this software assists the researcher in producing an animated video of the highest quality. The researcher uses the Google Firebase platform to build mobile and online applications. It provides Cloud Functions, which make use of a serverless framework to instantly

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execute backend code in response to events brought on by Firebase features and HTTPS requests. User JavaScript or TypeScript code is performed in a controlled environment using Google's cloud storage.

4.2 SafeSteps Modules

There are 5 modules in Safesteps which are (i) Registration & Login Page, (ii) Homepage, (iii) Lesson Module, (iv) Quiz Module and (v) Leaderboard Page.

Registration & Login Page

Fig. 3 shows the screenshot of the registration and login page. Every new user must fill in all their information such as full name, age, email, and password before clicking the register button. To access the application, an authorized user must enter a valid email.

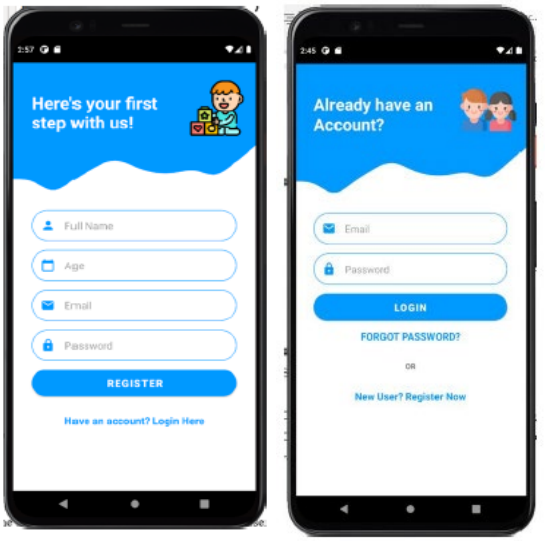

Fig. 3. Registration and Login Page

Homepage

Fig. 4 displays the home page. Users can select learning topics and view other users' accomplishments on this page. The attractiveness concept of persuasive technology has been applied in this section. The application is more likely to persuade since it is visually appealing to the intended user. The system uses relevant icons that are simple for users to recognize and comprehend. To help the user read efficiently, colour is also vital. The system uses a light colour scheme before using dark colours for each word. To prevent the user from getting bored while reading, the text font is also picked based on their preferences. To enable quick and simple identification by the user, this strategy just displays the fundamentals.

As principle of multimedia is being applied, this mobile application has been designed to look more appealing than one that only uses text by combining words and icons. Users may also comprehend concepts more rapidly if words and icons are used in conjunction. For instance, the play button is simpler for users to notice when the word "Click to Play" and the icon "Play" are used.

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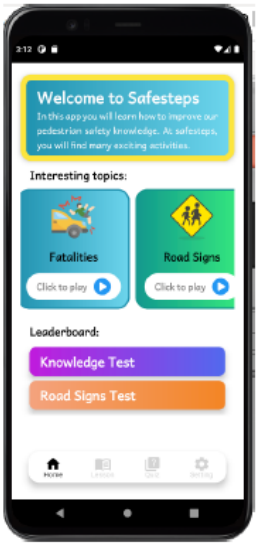

Fig. 4. Homepage

Lesson Modules

Fig. 5 displays the screenshot of the lesson page. This webpage comprises four educational materials modules for users to acquire knowledge. The user has the ability to choose the specific lesson they wish to acquire. To access the instructional video on the designated lesson page, the user may initiate playback by selecting the play button. Additionally, users have the option to choose from any of the buttons located at the bottom of the page to navigate to a different lesson or return to the main menu.

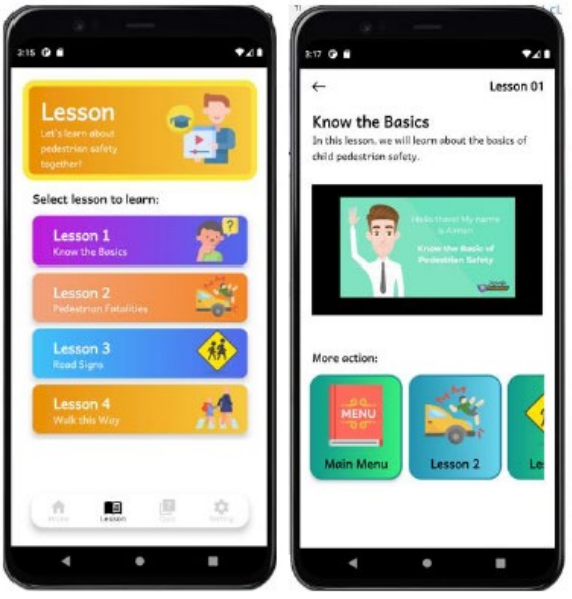

Fig. 5. Lesson Page

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The application of persuasive technology principles, such as cause and effect, is evident in this section. SafeSteps has the capability to capture the users' attention by highlighting the causes and effects of symptoms within a learning framework that emphasizes the causes and effects of pedestrian accidents. In the second video lesson, participants were presented with an examination of the causes and consequences of pedestrian accidents, alongside insights and recommendations for addressing this issue. The application of the multimedia principle, specifically interactivity, has been implemented in this particular section. The utilization of media controllers in learning videos allows users to control the presentation.

Quiz Module

Fig. 6 shows the screenshot of the main menu of the quiz page. This page comprises of two quizzes, namely the knowledge test and the road signs test. The user has the ability to choose the specific quiz they wish to undertake. The application of persuasive technology principles, such as attractiveness, has been implemented in this particular section. The system exhibits a visually pleasing interface that is specifically designed to cater to the preferences of the intended user.

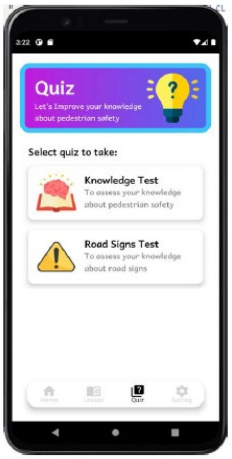

Fig. 6. Main Menu of the Quiz Page

Consequently, this aesthetic appeal is expected to enhance the system's persuasiveness. The application utilizes icons that are appropriately selected to ensure ease of recognition and comprehension by users. The utilization of colour plays a significant role in facilitating effective reading for the user. The system employs a light colour theme, complemented by the strategic use of dark colours for individual words. The selection of the text font is also determined by the user's preferences in order to prevent reader fatigue. This approach exclusively presents the fundamental elements, enabling the user to promptly and effortlessly discern them.

Fig. 7 displays the screenshot of the quiz page. The application of persuasive technology principles, specifically tailoring, has been employed in this section. Tailoring is employed as a means of customizing information or attributes to align with the individual preferences of the user. This application offers a "Share" feature that enables users to distribute quiz questions they find challenging to other users via various applications, including Telegram, email, and WhatsApp. In addition, this application incorporates functionalities such as the provision of the correct answer in the event that the user responds incorrectly to the quiz. This feature enables users to promptly discern the accurate answer or choice without necessitating the completion of the quiz.

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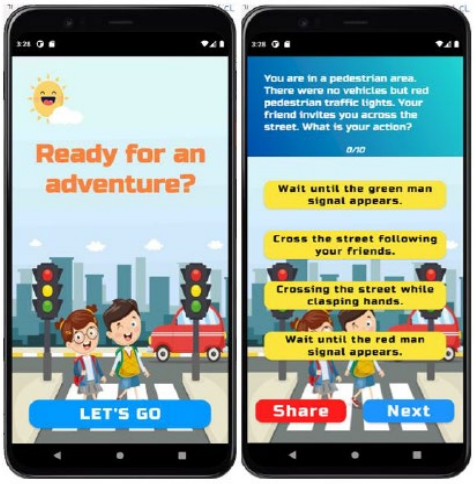

Fig. 7. Screenshot of Quiz Page

Leaderboard Page

Fig. 8 displays the screenshot of the leaderboard page. In this section, the principle of persuasive technology, specifically attractiveness, has been applied. The mobile application exhibits a visually appealing interface that is specifically designed to cater to the preferences of the target user. Consequently, it is highly probable that the system's aesthetic appeal will enhance its persuasiveness. The system utilizes icons that are appropriately selected to ensure ease of recognition and comprehension among users.

The utilization of colour plays a significant role in facilitating effective reading for the user. The system implements a light colour scheme, followed by the incorporation of dark colours for individual words. The selection of the text font is also determined by the user's preferences to mitigate potential reader fatigue. This approach selectively presents the fundamental elements, enabling the user to promptly and effortlessly discern them.

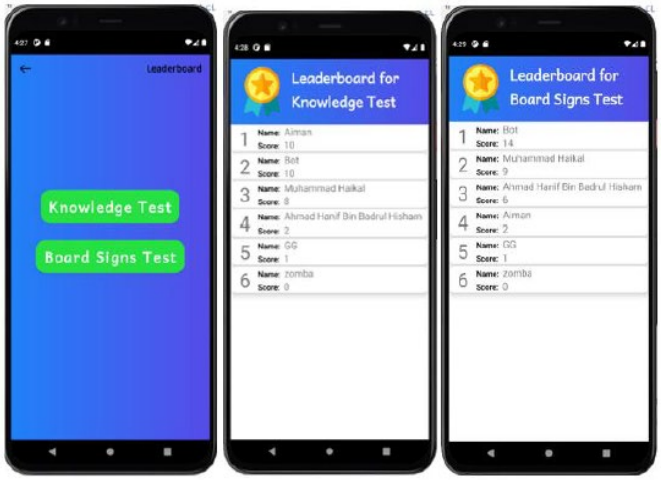

Fig. 8. Screenshot of Leader Board Page

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5. RESULTS AND DISCUSSION

In this study, User Experience Testing (UXT) was utilized to evaluate various aspects of user experience to determine the best way for the application and its elements to interact with its audience. The study involved thirty-one (31) participants, all of whom were school-aged children (6 to 12 years old). Users were given the opportunity to explore and evaluate the application during the UXT.

The results of this test were used to learn how the children feel when interacting with the application. Following application exploration, a questionnaire regarding the user experience aspects of this application is distributed so that all users could evaluate the application. User Experience Questionnaire (UEQ) is utilized as the instrument for the questionnaire.

5.1 User Experience Questionnaire

This survey aims to evaluate the user experience aspect of an interactive application and allow users to express feelings, impressions, and attitudes that arise while using the application (Santoso et al., 2016). The responses were rated on a 7-point Likert scale. The answers ranged from -3 (strongly agree with the negative term) to +3 (strongly agree with the positive term). The UEQ measures 6 aspects. The aspects that UEQ measures in this testing are (i) Attractiveness, (ii) Perspicuity, (iii) Efficiency (iv) Dependability (v) Stimulation and (vi) Novelty. In this test, there were 26 items asked, consisting of a pair of terms with opposite meanings, for example:

Boring……. Exciting

Efficient……. Inefficient

The concept of attractiveness pertains to the holistic perception of an application, irrespective of users' personal preferences or aversions towards it (Schrepp et al., 2017). Perspicuity refers to the evaluation of the extent to which a user will perceive the application as easily comprehensible and be able to acquire the necessary knowledge and skills to operate it proficiently. Efficiency can be defined as the capacity of users to accomplish their tasks with minimal exertion (Schrepp et al., 2017).

Dependability pertains to the extent to which the user perceives a sense of control during their interaction with the application (Schrepp et al., 2017). The level of stimulation experienced by a user plays a crucial role in determining their level of excitement and motivation to engage with an application. The concept of "novelty" pertains to the capacity to assess the innovativeness, creativity, and attention-capturing potential of a product [19]. The UEQ results were analyzed using the UEQ Data Analysis Tool Version 10. This tool aids in describing the essential characteristics of the data in this study. The mean score and variance for each UEQ scale is shown in Table 1 and Fig. 9.

Table 1. Mean Score and Variance for Each UEQ Scale

Scale	Mean Score	Variance
Attractiveness	1.989	0.61
Perspicuity	1.863	0.68
Efficiency	1.839	0.83
Dependability	1.435	0.67
Stimulation	1.782	0.46
Novelty	1.024	0.72

Based on Table 1, the mean score for the attractiveness scale is 1.989, indicating a positive evaluation. This suggests that SafeSteps may look attractive to the users. The children also may feel that this mobile application is enjoyable, good, pleasing, and friendly. The mean score for the perspicuity scale is 1.863,

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representing a positive evaluation. This shows that the mobile application is easy to understand, clear, simple, and easy to learn.

The efficiency scale obtains a mean score of 1.839, which indicates a positive evaluation. This suggests that the users can perform the tasks with the application quickly, efficiently and pragmatically. The mean score for the dependability scale is 1.435, which indicates a positive evaluation. This shows that the users' interaction with SafeSteps is predictable, secure, and meets their expectations.

The application also supports the users in carrying out the tasks given. The stimulation scale obtains a mean score of 1.782, indicating a positive evaluation. This demonstrates that the users have the impression that SafeSteps is valuable, interesting, exciting, and motivating. The mean score for the novelty scale is 1.024, representing a positive evaluation. This signifies that this mobile application is innovative, inventive, leading-edge, and creatively designed.

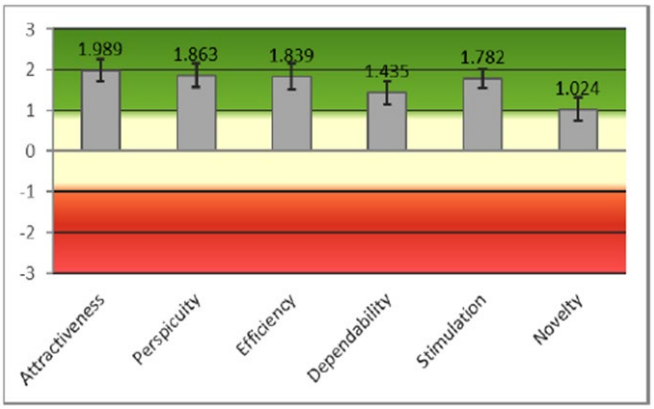

Fig. 9. Mean Score for each UEQ Scale

Based on the UXT results and findings, most users had a positive and pleasant experience using SafeSteps. Most users believe this system is attractive, perspicuity, efficient, dependable, stimulating and novel. Most of them also agreed that this application is motivating to raise awareness regarding pedestrian safety among children. All suggestions and recommendations from the participants during the testing have been taken into consideration. As a result, a few changes have been made based on these suggestions to improve this mobile application.

6. CONCLUSION

This research was carried out with the purpose of designing and developing SafeSteps, a mobile application that has the ability to educate children about pedestrian safety. This application also includes a quiz to reinforce previously learned information, cater to risk-taking behaviour problems, and raise safety awareness among young pedestrians.

Several recommendations and suggestions for future research can be implemented to enhance this study. One potential suggestion is to enhance the language support of this application by incorporating languages beyond English, such as Malay. This adjustment is particularly relevant considering that a significant portion of users, particularly children, continue to encounter difficulties with the English language. In addition, the participants expressed a desire for additional lessons due to the limited number of four (4) lessons available in this application, as indicated by the feedback received.

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Multimedia elements such as audio should be included in this application to make it more interactive. There is a need to increase the number of participants, with a specific focus on school-aged children, in order to enhance the validity and generalizability of the findings. Additionally, it is advisable to seek the evaluation of a greater number of experts in the fields of Human-Computer Interaction (HCI) and content expertise to ensure a comprehensive assessment of the application. Increased responses could potentially enhance the application's refinement and foster greater utilization among individuals.

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8. CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

9. AUTHORS' CONTRIBUTIONS

Nadia Abdul Wahab carried out the research, wrote and revised the article. Muhammad Aiman Azhar designed and developed the mobile application. Aznoora Osman conceptualised the central research idea. Norfiza Ibrahim designed the research and supervised research progress. Azmi Abu Seman tested all the components of the mobile application. Siti Sarah Md Ilyas anchored the review, revisions and approved the article submission.

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