# Usability Heuristic Evaluation of Mobile Learning Applications Based on the Usability Design Model for Adult Learners

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*Abstract*—Adult ownership of mobile devices has exploded over the past few years, and smartphones and tablets have become vital for communication, productivity, entertainment, and learning. Some common problems adults face are that they find it difficult to use new technology-based apps because many devices are small. Tasks on new technology-based apps take longer to complete. Therefore, the usability design model for adult learners has been proposed. The objective of this study is to evaluate the usability design model for adult learners and whether the applications containing the model components will affect the satisfaction of adult learners. The evaluation was based on the heuristics guidelines by Nielsen and has been modified and mapped with the seven components in the model. Two existing mobile learning (m-learning) applications (Duolingo and Lingualia) from the Play Store have been chosen for this evaluation. The results indicate that Duolingo has an overall satisfaction mean score of 4.38 compared to Lingualia, where the score is only 2.43. Duolingo meets most of the model's criteria and can score a higher satisfaction mean score. This indicated that the seven components play important roles in contributing to satisfaction among adult learners.

*Keywords—Usability design model; mobile learning; adult learners; heuristic evaluation*

## I. INTRODUCTION

Mobile learning (m-learning) is quite popular in today's educational world, and many scientists have recognized the potential of mobile technology to enhance learning. The continuous and rapid growth of mobile technology has transformed the traditional education setting into a more accessible, flexible, and personalized learning mode. Such learning benefits adult learners the most because they often face unique challenges, such as time constraints, where they need to balance their work and family commitments.

Moreover, m-learning applications can potentially enhance adult students' learning experience by providing timely, 'just-in-time' resources relevant to their particular needs and lifestyles. In the case of adult learners, the usability of these applications is critical to their design and development. If the applications are not easy to use, unintuitive, or inappropriate to their cognitive and physical needs, it can cause them to struggle to use m-learning. Adults face a number of challenges when using new technologies. People frequently lose various cognitive abilities as they age. Cognitive barriers, such as

slower information processing and memory recall, cause difficulties with complex systems and unfamiliar digital interfaces. As a result, using technology or interfaces can be more difficult for older adults, especially when they require adjustments to their perception, movement, or thought processes [1]. Usability Heuristic Evaluation (HE), a recognized method in user-centred design, serves as an effective framework for evaluating and enhancing the user experience of m-learning applications.

The objective of this study is to evaluate the usability design model for adult learners and whether the applications containing the model components will affect the satisfaction of adult learners. The evaluation was based on the heuristics guidelines by Nielsen and has been modified and mapped with the seven components in the model. Two existing m-learning applications (Duolingo and Lingualia) from the Play Store have been chosen for this evaluation.

## II. LITERATURE REVIEW

### A. Mobile Learning

Note that m-learning describes education using a mobile device. The idea encompasses "gaining knowledge in various environments, through social and content interactions using personal electronic devices" [2]. Furthermore, m-learning lets learners join in informal learning anytime and anywhere. It gives students control over their learning by offering access to different multimedia materials and chances for group learning and research [3]. Other than that, m-learning allows learners to do many tasks at different places and times. It provides educational content to help learners learn outside the classroom and boost their advanced thinking abilities [4].

Abduljawad and Ahmad [5] study the evolution and integration of m-learning into educational practices. Mobile learning faces challenges wherein teachers do not understand how to utilize mobile technology; security and privacy issues might arise because of connectivity restrictions; and the perfection of teachers using mobile devices creates some technical deficiencies. More problems related to the need to detail the development of efficient pedagogical content strategies and create comprehensive user interfaces. Mobile applications are increasing day by day and the software that used to rule earlier is getting outdated which is leading to compatibility issues. In the end, the study depicts m-learning as

an innovative, accessible, and flexible way to advance learning opportunities in the education system.

Olga Viberg & Åke Grönlund [6] study focuses on the design requirements for mobile applications in second language learning within online distance education. It highlights that students frequently use personal mobile technologies for self-initiated learning. Besides that, the study includes the challenges and strategies students face when using technology for language learning in both formal and informal educational settings. Furthermore, it emphasizes the importance of technology in supporting successful language learning processes and the need to provide instructional materials that are compatible with students' technological habits. Overall, the study provides useful insights into the use of mobile technology in language learning, as well as its impact on course design and teaching methodologies.

### B. Usability for Adult Learners

Finger gesture interaction with multi-touch surfaces has become more common. Frustrations with using touchscreen technologies are not only reported by older users, but younger groups also find difficulties, though they are typically better at adapting to technological changes [7]. Therefore, movements appropriate for older users may differ significantly from those designed for younger users [8]. Pointing and sliding (scrolling) tasks on the touchscreen, as well as the small size of the buttons, were more difficult for older adults than younger adults [9].

As they age, several people experience decreased ranges and levels of skills like vision, hearing, haptics, cognition, and adeptness, which may negatively impact their use and interaction with user interfaces [10]. Common user interface issues include misinterpretation of general icons, long task completion times, poor task efficiency, errors when reading text due to small font size and poor colour distinction, and confusion with output inputs [11-13]. Although this is usually the case, improving the design to enhance usability for older learners can also improve usability for other user groups [14].

### C. Heuristic Evaluation

Nielsen and Molich developed HE, which involves a small group of experts reviewing an interface based on key usability principles. At least three to five evaluators are usually recommended, as this group can identify approximately 65% to 75% of usability issues [15, 16]. Heuristic tests are typically performed during development, but running them on an operational, deployed system can improve how well it detects usability issues [17-19]. According to Nielsen, HE is quick, cost-effective, and simple because it relies on knowledgeable domain experts who efficiently assess usability [19, 20].

### D. Duolingo

In November 2011, Cambridge Mellon University's Luis Von Ahn and Severin Hacker released the free language learning app Duolingo. This app provides 68 different language courses in 23 languages, including French, German, Spanish, Dutch, and others, to help learners learn and acquire a foreign or second language. The learning interface is easy to use because it feels and looks like a game. In addition to dictation and written learning, Duolingo provides speaking practice for users who have attained a specific level. Applications for iOS,

Android, and Windows Phone are made to improve users' ability to communicate anywhere, at any time. Furthermore, Google Play presented Duolingo with the esteemed Best of the Best 2013 award [21].

### E. Lingualia

Lingualia-Learn Languages [22] is an educational app created in 2012 by Javier Sanchez, Roberto Zamora, and Sergio Blanco. Leaner has been able to download the APK since December 2013. Lingualia, a novel and cutting-edge language learning method based on artificial intelligence, adapts to students' interests, motivations, progress, and free time. In addition to all of this information, it can tailor students' learning to meet specific needs. Lingualia allows students at all skill levels (beginner, intermediate, and advanced) to learn Spanish or English. Using cutting-edge technology, educators developed all of the multimedia content. Lingualia contained more than 400 language lessons, 25,000 pronunciation audios, 10,000 vocabulary words, pronunciation guides, grammar, and 100 online language practice exercises.

## III. COMPONENTS IN THE USABILITY DESIGN MODEL FOR ADULT LEARNERS

The usability design model for adult learners includes seven components, as shown in Fig 1: usability layout, navigation, content, a touch gesture, andragogy, and scaffolding.
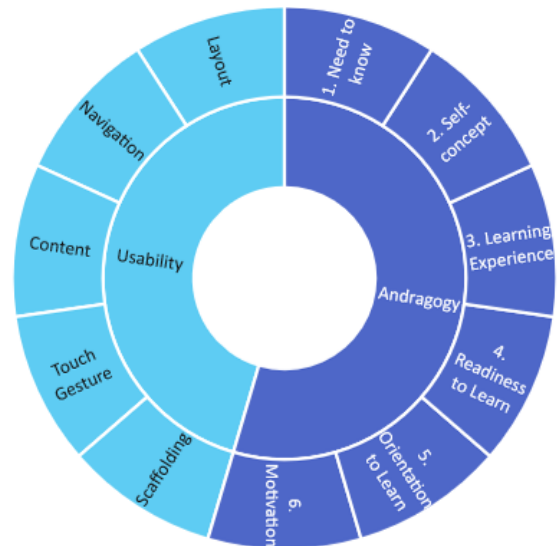


Fig. 1. Usability design model for adult learners.

### A. Usability

The concept of usability has been defined in several ways, and providing teaching and learning services through mobile devices is one of the required aspects. Usability focuses on how computer-related systems communicate with humans [23, 24]. In this study, usability refers to suitable usability for adult learners concerning inability and motor skills.

### B. Layout

Application layout refers to the device structure that users see. The consistent page layout will allow users to quickly understand how the application works [23, 25]. Aside from that, all application interfaces must have a simple and consistent

layout that adapts to any smartphone or tablet screen size and is easy for the user to manage.

### C. Navigation

Navigation is essential in managing the learner's mood while interacting with the program. Using the navigation feature, learners are able to easily move around the application, making it simpler for them to go from one page to another. Complicated navigation can present challenges for users when using the application. It is not advisable to use complex navigation systems [26]. By including clear navigation in the application, users will have an easier time learning the application process. Hence, having a fixed menu bar on every application interface is important.

### D. Content

Learning activities would take place on mobile. The small screen size of mobile devices makes it difficult for users to read lengthy content [27]. Content should be compact, concise, and straightforward. Mobile devices have limited screen space, so a simple design allows learners to access information without scrolling or zooming excessively. Simplifying content can reduce cognitive load and allow learners to focus on learning objectives. Besides that, choose bright and colourful colours to create the content, making the icons appealing.

### E. Touch Gesture

Pointing and sliding (scrolling) tasks on the touchscreen, as well as the small size of the buttons, were more difficult for older adults than younger adults. Older adults may find certain gestures, such as pressing and holding, sliding, pinching/spreading, and rotating, too difficult [8, 28, 29]. However, tap and swipe gestures are recommended for older users as they are easy to use and understand [28, 29]. Therefore, it is important to include appropriate touch gestures for adult learners within the application to ensure that they can use it without becoming stressed or demotivated.

### F. Theory of Andragogy

In the late 1960s, Malcolm Knowles introduced the term "andragogy" to define his approach to adult education [30]. Adult learning theory is important in designing instructional material to ensure the model suits the adult learner. Andragogy theory has been applied in global studies, resulting in literature translations in multiple languages. This approach to andragogy is effective for individuals of all ages, genders, and nationalities [31].

*1) The learner needs to know why they need to learn something:* Adults need to understand why they are learning something. They will feel more driven when they know what they should pick up. It can help them grasp the point of the lesson by zeroing in on what they want to learn or how they plan to use it in their lives [32]. Therefore, it is important for the learners and facilitator to communicate with each other. To ensure learners understand why they need to learn something, facilitators must give feedback about how useful the ongoing learning is throughout the course.

*2) The learner (self-concept):* Adult learners learn new information and enhance their current knowledge more efficiently when motivated to investigate a subject independently. This could be in the form of individual or group projects that require only minimal input from the teacher. The self-concept learner plays a key role in determining performance in a distance learning setting [33]. Hence, collaborative activities that support and encourage adult learners are recommended. Collaborative activities allow adults to showcase their skills and are consistent with the principles of andragogy [34].

*3) Adult learning experiences:* Every adult has accumulated a lifetime of experiences and may desire to apply their expertise and receive recognition for their knowledge. Examples of learning activities like case studies, group projects, reflective tasks, and short writing exercises can help learners utilize their existing knowledge through sharing and reflection. They are more likely to remember what they have read when they connect it to their own experiences [32, 35]. When learners connect their lives to their reading, they are more likely to remember what they read. As a result, it is important to link assignments or projects to real-life experiences.

*4) Readiness to learn:* Knowles [30] states that adults need to learn to cope more satisfactorily with real-life tasks or problems. This showed that adults were willing to learn as long as it was connected to their social development. If they realize that certain new learning opportunities can enhance their skills, they are more inclined to push themselves to acquire additional knowledge. Social networking platforms and digital collaboration tools aid adults in integrating this belief into their final projects. Hence, designing tasks that prompt adult students to utilize blogs, wikis, or other social platforms can assist them in not just expanding their social circle but also in working together with individuals who have similar interests. Socializing is essential for connecting users to social networking platforms.

*5) Orientation to learn:* Adults focus on solving problems when they learn. Learning is based on real-life scenarios or job-related situations rather than specific academic topics. Highlighting how the topic will address issues commonly faced by adult learners in their personal or professional lives through the use of real-life situations is crucial [32]. Using real-life situations related to their life makes it more effective. Media is the most effective way to provide a tangible example or scenario that individuals may encounter in real life.

*6) Motivation to learn:* Knowles believed that adults were most motivated to achieve their educational goals when acknowledged and appreciated for their contributions to the class [36]. Increased job satisfaction, self-esteem, and quality of life are critical in motivating adults to learn [32]. To motivate adults to learn, the learning environment should encourage active participation. Games, quizzes, and multimedia have all been used effectively to boost learner motivation [35]. Recognizing learners' contributions to the course will boost their self-esteem, motivating them to succeed in their coursework [37]. Therefore, it is important to let them know a reason for every activity, assessment, or e-learning module they

need to complete and acknowledge them after they contribute their effort.

### G. Scaffolding

Scaffolding divides complex tasks or competencies into smaller components that will be completed one at a time. This reduces the stress and difficulty of the task while also allowing adult learners to track their progress. Scaffolding is especially important for first-year adult students who may require additional assistance as they transition to an academic setting [38].

### IV. COMPARISON OF MOBILE LEARNING APPLICATIONS BASED ON THE USABILITY DESIGN MODEL

Duolingo and Lingualia, two different m-learning apps available on the Play Store, were compared. Both m-learning apps provide language courses based on the m-learning model's seven components: usability, layout, navigation, content, touch gesture, andragogy, and scaffolding for adult learners.

In this study, usability refers to how well the system works for adult learners. When developing m-learning, it is necessary to consider adult learners' motor skills and limitations. It is possible that movements designed for younger users will not work well for older users. The term layout refers to a m-learning interface that is simple and consistent. A simple and consistent layout is easier to control than a complicated layout, which confuses the user. Duolingo provided the user with guidance information that was simple, consistent, and understandable. Despite the fact that a simple and consistent layout is easier for users to control, Lingualia's mobile application is overly simple and lacks information.

Navigation is defined as simple, consistent, and stagnant. Duolingo's navigation design is straightforward, simple, consistent, and stagnant. Each application page has a fixed size, colour, and location. However, in Lingualia, the navigation was designed as a kebab menu (hidden menu), and not all pages included the menu. Aside from that, the Lingualia mobile app provides less navigation information. Duolingo offers simple, accessible, and concise content design. The bright and colourful colours used in the content design make for attractive icons. The information displayed on the screens is simple to view, read, and comprehend, unlike Lingualia, which uses plain colours and simple icons to design its content.

Touch gestures refer to using appropriate touch gestures with an adult learner. The majority of Duolingo and Lingualia's touch gestures are designed to allow users to interact with the mobile application by tapping. It is simple to use and consistent, and the button size is suitable for finger touch for adult learners. However, some of Lingualia's button designs are small compared to Duolingo's.

Andragogy is made up of six assumptions. For the first assumption, the learner needs to know why they need to learn something. Duolingo offers basic information about outline contents, whereas Lingualia does not. The second assumption is that learners are motivated to learn. Adult learners are motivated to learn when there is a clear connection between the information provided and their personal experiences. Using a game that is relevant to their lives and setting a reward for success can help the adult become more motivated. In contrast to Lingualia, Duolingo has set the reward if the user successfully completes the level. Even though Lingualia offers a learning game, the user does not receive any rewards.

The third assumption in andragogy theory is the learner (self-concept), which states that adult learners prioritize their learning and do not rely solely on their teachers. The use of mobile applications should be learner-focused. Both Duolingo and Lingualia were created to break down learning into manageable portions that can be completed in a short time, with logical stopping and starting points. The use of mobile applications is extremely convenient, especially in terms of timing, as adult learners can direct their learning from anywhere and at any time.

The next assumption is adult learning experiences, in which adult learners enjoy sharing their experiences with others. Duolingo provided a forum where users could share their experiences and connect with friends using their Facebook accounts or email addresses. In these terms, Lingualia did not provide a user interaction or sharing platform.

The fifth assumption is readiness to learn. To meet this assumption, a content syllabus relevant to real-world scenarios and an outline of the learning objectives would be useful. Both Duolingo and Lingualia offered activities that were applicable to real-world situations. The final assumption is an orientation to learn. Adults prefer problem-based learning relevant to real-world situations, such as connecting activities or tasks to real-life scenarios. Duolingo and Lingualia included a game inspired by a real-life situation in this section. Duolingo, unlike Lingualia, provides a simple explanation of how the learner will apply the course material in their daily lives.

Scaffolding is an instructional strategy in which the learner receives external support in person or through artifacts to achieve learning goals and tasks within the zone of proximal development until the learner is able to perform the task independently. Duolingo provided clear instructions and effectively conveyed information when using the mobile application, whereas Lingualia provided less instruction.

### V. METHODOLOGY

This study applied HE based on the usability engineering methodology. The heuristics guidelines were modified and mapped to the seven components. The goal of this study is to evaluate the existing m-learning design using Nielsen's heuristics guidelines to determine whether the m-learning application containing the model's components is able to give satisfaction to adult learners.

### A. Experts

In this study, seven experts are involved in evaluating the m-learning application, which is acceptable, as suggested by Nielsen [17], where the minimum number of experts can be three. Table I presents the details of the experts involved in the evaluation process. Fig. 2 illustrates the pie chart of the experts' total percentage of years of service experience.

TABLE I.     EXPERT DETAILS INVOLVED IN THE EVALUATION

| *Experts* | *Position* | *Expertise* | *Year of Experience* |
|---|---|---|---|
| Expert 1 | Mobile App Developer | Mobile Application, Information Technology, Human-Computer Interactions | Less than 5 |
| Expert 2 | Lecturer | Mobile Learning / App; Information Technology | 6 – 10 years |
| Expert 3 | Lecturer | Information Technology | More than 11 years |
| Expert 4 | Lecturer | Information Technology | 6 – 10 years |
| Expert 5 | Lecturer | Information Technology | More than 11 years |
| Expert 6 | Lecturer | Mobile Learning / App; Information Technology; E-Learning & Education | More than 11 years |
| Expert 7 | Lecturer | Mobile Learning / App; Data Science and Machine Learning | 6 – 10 years |

## TOTAL PERCENTAGE OF YEARS' SERVICE EXPERIENCE

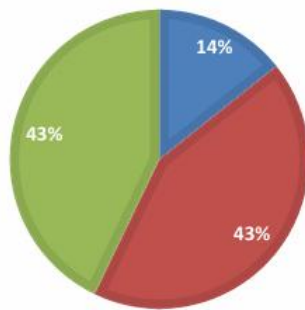■ 1 -5 years   ■ 6 - 10 years   ■ 11 - 20 years

14%
43%
43%

Fig. 2.   Total percentage of years of service experience.

### B. Questionnaire

The questionnaire for evaluating the m-learning application was based on HE. Nielsen's heuristics guidelines were chosen, modified, and mapped to the seven components based on how appropriate they are for this study to ensure that the m-learning application contains the model's components. Table II presents the heuristic rules mapped to the model's seven components. Questionnaires were designed to elicit responses using a five-point Likert Scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

TABLE II.     HEURISTIC RULES MAPPED WITH THE COMPONENTS IN THE MODEL

| *No* | *Heuristic Rules* | *Components* |
|---|---|---|
| 1. | User control and freedom | Usability, Navigation, Content, Touch Gesture |
| 2. | Error prevention | Scaffolding |
| 3. | Consistency and standards | Layout, Navigation, Touch Gesture |

| *No* | *Heuristic Rules* | *Components* |
|---|---|---|
| 4. | Aesthetic and minimal design | Layout, Navigation, Content, Touch Gesture |
| 5. | Suitability | Usability, Layout, Navigation, content, touch gesture |
| 6. | Help and Documentation | Andragogy |
| 7. | User Satisfaction | |

### C. Evaluation Process

The first step in the evaluation process was to identify the number of the expert, which was then reached via email or phone call. An appointment was made with those who agreed to participate in the evaluation process. The experts entered their background information and began to evaluate the mobile application using the provided questionnaire and description of how the procedure was carried out. After the expert had completed the evaluation process, the researcher analyzed the findings and arrived at the results and conclusion.

## VI. RESULT AND DISCUSSION

Duolingo has a mean score of 4.46 for user control and freedom, compared to Lingualia's 2.91. Duolingo's design enables adult learners to manage the application easily. Duolingo outperforms Lingualia in error prevention with clear and easy-to-understand instructions, where the mean score is 4.45 for Duolingo and 2.39 for Lingualia. Table III lists the result of the mean score for Duolingo and Lingualia.

TABLE III.     RESULT OF THE MEAN SCORE FOR DUOLINGO AND LINGUALIA

| *No* | *Heuristic Rules* | *Duolingo* | *Lingualia* |
|---|---|---|---|
| 1. | User control and freedom | 4.46 | 2.91 |
| 2. | Error prevention | 4.45 | 2.39 |
| 3. | Consistency and standards | 4.29 | 3.00 |
| 4. | Aesthetic and minimal design | 4.48 | 2.45 |
| 5. | Suitability | 4.20 | 2.43 |
| 6. | Help and Documentation | 4.27 | 2.16 |
| 7. | User Satisfaction | 4.38 | 2.43 |

Consistency and adherence to standards in application development help create user-friendly experiences, reducing confusion and improving the ease of learning. Duolingo's design is consistent and standard, and the bar chart portrays that Duolingo's mean score is higher than Lingualia's, where the mean score is 4.29, while Lingualia's score is 2.90. Aesthetics play an important role in the perception and memory of application designs.

In addition, for minimal, it maximizes utility and usability by allowing users to find what they need. In other words, interfaces should not include irrelevant or rarely used information. Duolingo scored 4.48 on aesthetic and minimal design, while Lingualia scored 3.00. Duolingo is better suited for adult learners, with a score of 4.2 versus Lingualia's 2.43. Duolingo earns a 4.27 rating for its comprehensive support and documentation resources. Lingualia has fewer guidelines and a lower score, with a mean score of 2.16. Fig. 3 shows that

Duolingo has a higher overall satisfaction mean score of 4.38 than Lingualia, which is 2.43. Duolingo meets most of the model's criteria and offers higher user satisfaction. According to the study's findings, it shows that the user satisfaction is higher with m-learning applications that include a greater number of these model components. Applications with fewer components, on the other hand, may fall short of meeting the diverse needs of adult learners. The findings also highlight the significance of including comprehensive model components during the design phase of m-learning applications.
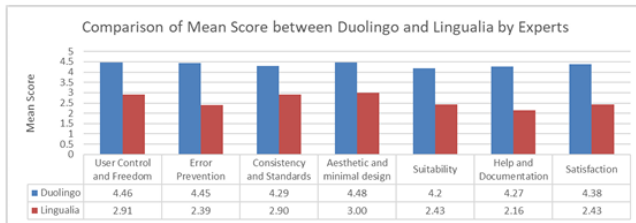


Fig. 3.    Comparison of mean score between duolingo and lingualia.

## VII. CONCLUSION

This study compares two different m-learnings available in the Play Store, Duolingo and Lingulia. The purpose of this study is to evaluate the existing m-learning design based on Nielsen's heuristics guidelines. The heuristics guidelines have been modified and mapped with the seven components in the model to validate whether the m-learning application containing the model's components can give adult learners satisfaction. Moreover, the results indicate that the m-learning application containing the component in the model is able to score higher satisfaction to adult learners compared to m-learning applications that contain fewer model components. This study will contribute to the growing body of work on m-learning by offering practical insights for design and development teams and educators who are trying to optimize usability with adult learners.

## ACKNOWLEDGMENT

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