HYBRIDISING SIGNALING PRINCIPLE AND NIELSEN'S DESIGN GUIDELINES IN A MOBILE APPLICATION

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ABSTRACT

Learning via mobile phone is very common nowadays, whether at the primary or tertiary stage. The use of mobile phones is causing growing concern among the general public. Improving online education, primarily via this device, is also one of the government's most pressing needs. Most current research on mobile learning applications pays little attention to multimedia principles, especially the Signalling principle, to improve user interaction. As a result, this project is undertaken to suggest better and more efficient mobile learning applications. The model is developed in collaboration with various stakeholders, including content experts, HCI experts, actual users, and a thorough literature review. Creating these mobile learning design guidelines is anticipated to lead to a more efficient and successful mobile learning style. According to the results of the experiments, implementing the hybridised guidelines resulted in a significant increase in Asmaul Husna Islamic knowledge among university students.

Keywords: Signalling Principles, Design Guidelines, Mobile Application, Mobile Learning, Islamic Mobile Learning Applications

INTRODUCTION

Compared to the computer, where the nature of usage mostly revolved around the job and home environment, mobile technology involved human-technology interaction in diverse and dispersed contexts (Karim et al., 2009) that are not bound by place and time. In the context of education, the shift of paradigm is necessary for this mobile technology to succeed. Some point out that parents and teachers need to encourage children to learn through cell phones under their supervision and monitoring; others are concerned about how this learning may be inappropriate and can lead to additional work for teachers (Ariffin et al., 2012). Educational uses of mobile technology, such as mobile phones, tablets, and laptops, have a massive impact on education (Dollah et al., 2017; Mayer, 2020).

Mobile learning applications only have a few design guidelines grounded in learning principles to ensure their effectiveness (Limtrairut et al., 2016). The existing design guidelines mainly targeted desktop applications unsuitable for mobile learning applications (Latiff et al., 2019). Mobile learning is a supportive learning medium and a principal learning medium between distinct learners (Jamaldeen et al., 2018). Therefore, in merging mobile learning into everyday teaching and learning, there is a need for a design that could frame the discussions and the implementations; this is to ensure all critical elements are comprised to produce effective interactions between students and the mobile learning environment (Rosmani et al., 2018a).

BACKGROUND

The Signalling Principle emphasises what is essential in the material presented (Mayer, 2016). It was expected that visual signalling techniques would alleviate the unnecessary load associated with the Cognitive Theory of Multimedia Learning's (CTML) selection phase, thus freeing cognitive resources for more essential processes such as information organisation and integration (Johnson et al., 2015). According to Van Gog (2014) and based on CTML, the combination of attention-guiding cues can significantly increase the effectiveness of educational materials (Schneider et al., 2018) and make learning more favourable, depending on student characteristics, teaching materials, and experimental procedures (Richter et al., 2016). The principle was deemed positive in guiding learners' attention. Some studies revealed that signalling enhanced visual search efficiency to find relevant information and improved learning performance, such as pointing gestures. It reduces extraneous processing by directing the learner's attention to critical elements in situations where the learner does not know where to (Davis, 2018). Hence, it is crucial to include cues such as colour-coding, labelling, and verbal references in multimedia learning environments (Alemdag & Cagiltay, 2018). The chosen principle is very significant in the learning context, especially in e-learning and multimedia presentations. This principle has been a success in the previous works on Asmaul Husna learning and memorisation through courseware and game (Rosmani, Gining, & Angwar, 2017; Rosmani & Zakaria, 2018). Based on the research, decent results were obtained using Signalling Principles, such as the students' engagement, excitement, and attractiveness in using the learning materials and learning the content. The Signalling principle applied in this particular research consisted of a visual signal consisting of prominent texts and colours, colour-coded cueing and text-based cueing, picture-based cueing and audio intonation in spoken text.

Nielsen's design guideline is well-known for its application and uses in human-computer interaction. Consequently, numerous studies have been conducted to develop an excellent mobile learning environment using these guidelines. However, none have adopted and utilised both the Signalling principle and Nielsen's design guideline in the manner intended in this study (Rosmani et al., 2020, 2018b). Table 1 demonstrates the learning materials that have been selected using only Nielsen's Usability Design Principles and Nielsen's Heuristics. Nielsen's design guidelines in the proposed model include visual design, writing, navigation, interaction design, and multimedia design principles.

TABLE 1. Application of Nielsen's Usability Design Principles and Heuristics

Author	Principle / Guideline	Context
Hu (2018)	Nielsen's Heuristics	Mobile Music Service
Inal (2018)	Nielsen's Heuristics	National Library of Turkey Website
Yen et al. (2018)	Nielsen's Heuristics	Commercial Inpatient Portal
Grzybowski, Minkowski and Olszewski (2017)	Nielsen's Heuristics	Mobile Telecare
Sability and Pettersson (2016)	Nielsen's Usability Design Principles and Heuristics	Mobile Web
Sharples (2014)	Nielsen's Heuristics	Mobile Learning
Gu, Gu, and Laffey (2011)	Nielsen's Usability Design Principles and Heuristics	Mobile Lifelong Learning • Expo English • Six-Step Change Tire

Babaian, Lucas, Xu and Topi (2010)	Nielsen's Usability Design Principles	Enterprise Resource Planning (ERP)
Desurvire and Wiberg (2009)	Nielsen's Usability Design Principles	Video and Computer Games
Chorianopoulos (2008)	Nielsen's Usability Design Principles	Interactive Television Applications
Boivie, Blomkvist, Gulliksen, Goransson and Cajander (2003)	Nielsen's Usability Design Principles	User-Centred Systems Design
Federoff (2002)	Nielsen's Usability Design Principles and Heuristics	Video Games

Asmaul Husna is the significant attribute and beautiful name of Allah, *asma* is the plural form of the word *ism*, which means name, and *husna* means good or beautiful. Therefore, the combination of Asmaul Husna means the most beautiful name of Allah. According to Murtadho (2012), from 99 names of Allah, there are 69 names found in the Holy Qur'an with different frequencies, ranging from 1 to 138 times. The other 30 names are located in the Hadith of the Prophet. Unfortunately, the public is unaware that Asmaul Husna contains beautiful meanings that can be used in everyday life either as a supplication or dhikr (Ab Rahman, 2016; Al-Qurtubi, 2017; Nik Mat, 2016; Wan Mohd, 2015). It has been supported by Surah Al-A'raaf verse 180, "And to Allah belong the best names, so invoke Him by them. And leave [the company of] those who practice deviation concerning His names. They will be recompensed for what they have been doing". It was also discovered that Muslims' knowledge and awareness of Asmaul Husna are entirely restricted (Abdul Mutalib et al., 2018).

THE GAP

Although previous studies have suggested that Signalling enhances multimedia learning, there is not enough evidence showing why Signalling leads to better knowledge (Ozcelik et al., 2010). Furthermore, the Signalling principle for multimedia learning lacks a comprehensive review, including relevant studies from different testbeds (Richter et al., 2016) and needs to be regarded in numerous moderators (Schneider et al., 2018). This limitation reveals the need for further investigations in specific signalling techniques, instructional materials, and participants (Schneider et al., 2018). Moreover, the signalling effect's cognitive processes and generalizability to young learners are indeterminate (Jian, 2018).

Based on these researches in Table 1, Nielsen's design guideline is selected for this study as it promises many benefits. In the initial investigation conducted, many of the respondents were aged 18-24 years old. Therefore, Nielsen's design guideline for this age category has been chosen. Besides, they are the majority of mobile phones user (Malaysian Communications and Multimedia Commission, 2017, 2018) and future generations who will eventually become leaders of the nation, their families or at least themselves. The usability suggestions are engaged from Budiu and Nielsen (2010), Kumar et al. (2019, 2020), Kumar and Mohite (2016), Loranger et al. (2014), Nielsen (1994a, 2012, 1994c), Nielsen and Budiu (2013), and Nielsen and Landauer (1993). These suggestions are considered in the designing and developing phase of this study.

A study has been conducted to investigate the knowledge and awareness of Asmaul Husna among randomly selected Muslims. Altogether, 55 respondents were involved in answering the survey. The respondents consist of 24 males and 31 females between below 20 to more than 50. Their education level varies between primary school and PhD. It is revealed

that the level of awareness and knowledge about Asmaul Husna among Muslims is still scarce (Abdul Mutalib et al., 2018). Therefore, there is a necessity to commence research on this context to confront the deficiency.

THE PROPOSED SOLUTION

As Signalling principles and Nielsen's design guidelines are two compelling principles, this study believes hybridising them contributes significantly to knowledge acquisition and motivation. While previous works are studied in various contexts, this study ventures into Islamic content, particularly Asmaul Husna. Furthermore, there is no evidence that Islamic mobile apps have integrated the Signalling principle. In practice, plausibly, the multimedia principles do exist. Still, the researchers might not focus, highlight, or emphasise these principles as they mainly considered the application's content (Rosmani et al., 2018b).

THE PROCESS

Henceforth, this paper's main objective is to illustrate the milestones of constructing a new interaction model for mobile learning. The construction process involves six main activities: content analysis, user requirements survey, hybridisation of design guidelines, consultation with experts, prototype development, and user testing. These activities' ultimate concern is to determine the main components of these design guidelines and their elements. To summarise those activities, Figure 1 illustrates the methods along with their objectives.
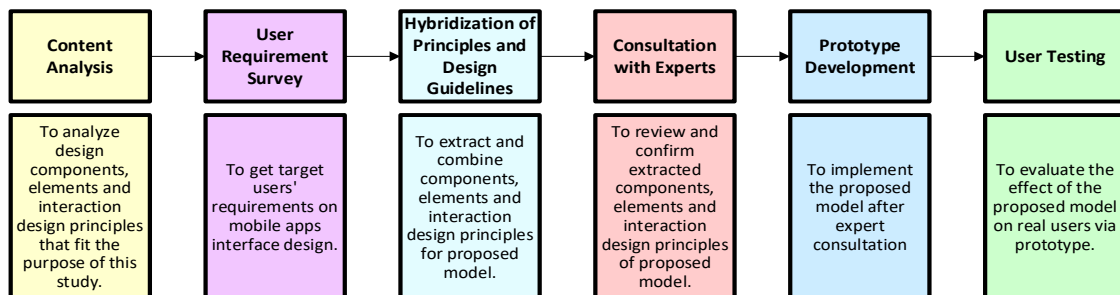
Content Analysis	User Requirement Survey	Hybridization of Principles and Design Guidelines	Consultation with Experts	Prototype Development	User Testing
To analyze design components, elements and interaction design principles that fit the purpose of this study.	To get target users' requirements on mobile apps interface design.	To extract and combine components, elements and interaction design principles for proposed model.	To review and confirm extracted components, elements and interaction design principles of proposed model.	To implement the proposed model after expert consultation	To evaluate the effect of the proposed model on real users via prototype.

FIGURE 1. The Milestones of Constructing the Interaction Model

The following section will detail out each of the processes involved.

CONTENT ANALYSIS

The content analysis involved sources of content that refer to the development of the interaction model. The primary information source is focused mainly on interviews with content experts and other related materials such as printed and online materials. All the materials collected are from a trusted and reliable party, e.g., articles and expert consultation. The other vital resource is for design and instruction, and the learning resources are books to ensure in the method of instructional design, verify that the app addressed the appropriate principles of digital design, as well as design guidelines for college students to provide the specific standards followed for the target audience who is the adolescents. Many previous projects have been designed and developed using and hybrid of various multimedia principles and aspects. None have hybridised the Signalling principle with Nielsen's design guideline (Rosmani et al., 2018b).

USER REQUIREMENT SURVEY

This survey was conducted to inspect the requirements of mobile application's elements as demanded by end-users between 18 and 24 years of age as they are the most popular mobile users (Malaysian Communications and Multimedia Commission, 2017, 2018). Questions in the survey are checked and validated by responsible parties to ensure the accuracy of the items. They are comprised of two PhD holders in Computer Science with more than ten years of experience and a software developer with a 6-years' experience. A total of 134 participants of the targeted age have participated in this survey. There are three subsections in this survey: demographics, required elements for mobile apps, and suggestions.

THE HYBRIDISATION OF DESIGN GUIDELINES

The Signalling principles and Nielsen design guidelines were hybridised into one mobile application mode, and the other mode is without the proposed design guidelines. The chosen principles are based on an astounding earlier investigation, as shown in Table 1, and these principles and design guidelines are tallied with the requirements of the target users. Referring to literature written by Hu (2018), Inal (2018), Yen et al. (2018), Grzybowski, Minkowski and Olszewski (2017), Sability and Pettersson (2016), Sharples (2014), Gu, Gu, and Laffey (2011), Babaian, Lucas, Xu and Topi (2010), Desurvire and Wiberg (2009), Chorianopoulos (2008), Boivie, Blomkvist, Gulliksen, Goransson, and Cajander (2003), and Federoff (2002), Nielsen's design guideline is selected for this study as it promises for:

1. Suitability for e-learning environments, especially for the mobile learning environment.
2. Cover the perspectives that are best suited for the development of learning applications.
3. Customisation, according to the learners' category.

The signalling principle is chosen as it is very significant in Asmaul Husna, especially in m-learning and multimedia presentations. The selected principle has been a success in the previous works on Asmaul Husna learning and memorisation through courseware and game (Rosmani et al., 2017; Rosmani & Zakaria, 2018). Based on the research, decent results were obtained using Signalling Principles, such as the students' engagement, excitement, and attractiveness in using the learning materials and learning the content. Therefore, based on the results in previous researches by Azam Khan and Simon Breslav (2018), Mayer (2017), Murphy and Liew (2016), Yang (2016), Ahmad and Wan Yahya (2015), Scheiter and Eitel (2015), Glaser and Schwan (2015), Johnson et al. (2015), Boucheix, Lowe, Putri and Groff (2013), and Johnson, Ozogul, Moreno and Reisslein (2013) the reason for the selection of this principle for this study is because past researches indicated that Signalling principles had supported learners in these aspects:

1. Improve learner's performance.
2. Reduce the learners' mental load.
3. Both high- and low-visualisers received equally good benefits.
4. Increase learners' knowledge achievement.
5. Provide benefits and assistance to the learners.
6. It makes learners focus on the most relevant content at a time or a chunk of information.
7. Suitable to be applied for visual learners.
8. Demonstrates that visual cue is most beneficial when applied in mobile learning environments.

Based on these findings, the guidelines are designed by combining all the essential and selected elements from the Signalling principle, Nielsen design guidelines and user requirements.

CONSULTATION WITH EXPERTS

Six experts from various public higher institutions are involved in this consultation purpose, as listed in Table 2. The proposed guidelines were printed in colour and A3 size and presented to each expert in person. After scrutinising the proposed model, they have suggested a few added or eliminated factors from the list.

TABLE 2. List of Experts

No.	Gender	Education	Fields of Expertise	Experience (Year)	Affiliations
1.	Male	PhD.	HCI, Usability	19	Universiti Utara Malaysia
2.	Male	PhD.	Software Engineering	14	Universiti Teknologi MARA
3.	Female	PhD.	Multimedia Systems, HCI	13	Universiti Utara Malaysia
4.	Male	PhD.	Interaction Design	14	Universiti Kebangsaan Malaysia
5.	Female	PhD.	Multimedia Learning	10	Universiti Utara Malaysia
6.	Male	PhD.	Instructional Design	21	Universiti Sains Malaysia

The model is then amended according to the suggestions and become the basis for prototype development. The newly proposed hybridised interaction model is as depicted in Figure 2.
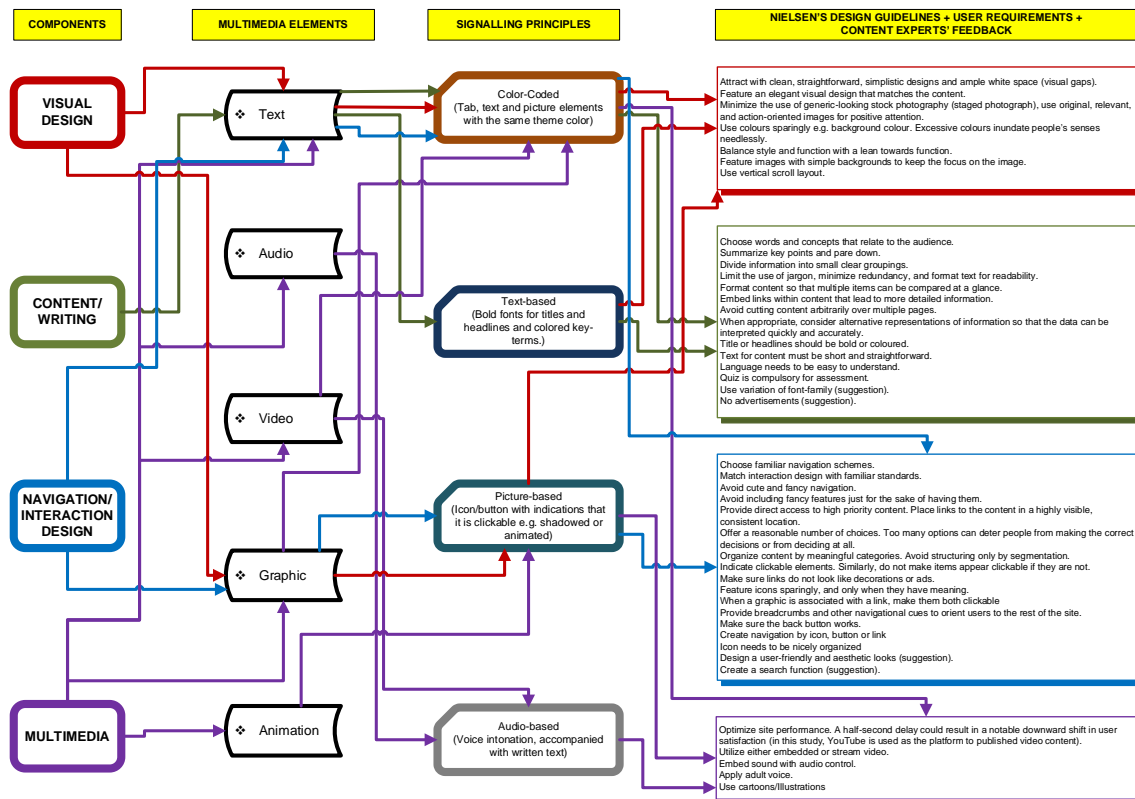
VISUAL DESIGN

CONTENT/ WRITING

NAVIGATION/ INTERACTION DESIGN

MULTIMEDIA

- Text
- Audio
- Video
- Graphic
- Animation

Color-Coded
(Tab, text and picture elements with the same theme color)

Text-based
(Bold fonts for titles and headlines and colored key-terms.)

Picture-based
(Icon/button with indications that it is clickable e.g. shadowed or animated)

Audio-based
(Voice intonation, accompanied with written text)

Attract with clean, straightforward, simplistic designs and ample white space (visual gaps).
Feature an elegant visual design that matches the content.
Minimize the use of generic-looking stock photography (staged photograph), use original, relevant, and action-oriented images for positive attention.
Use colours sparingly e.g. background colour. Excessive colours inundate people's senses needlessly.
Balance style and function with a lean towards function.
Feature images with simple backgrounds to keep the focus on the image.
Use vertical scroll layout.

Choose words and concepts that relate to the audience.
Summarize key points and pare down.
Divide information into small clear groupings.
Limit the use of jargon, minimize redundancy, and format text for readability.
Format content so that multiple items can be compared at a glance.
Embed links within content that lead to more detailed information.
Avoid cutting content arbitrarily over multiple pages.
When appropriate, consider alternative representations of information so that the data can be interpreted quickly and accurately.
Title or headlines should be bold or coloured.
Text for content must be short and straightforward.
Language needs to be easy to understand.
Quiz is compulsory for assessment.
Use variation of font-family (suggestion).
No advertisements (suggestion).

Choose familiar navigation schemes.
Match interaction design with familiar standards.
Avoid cute and fancy navigation.
Avoid including fancy features just for the sake of having them.
Provide direct access to high priority content. Place links to the content in a highly visible, consistent location.
Offer a reasonable number of choices. Too many options can deter people from making the correct decisions or from deciding at all.
Organize content by meaningful categories. Avoid structuring only by segmentation.
Indicate clickable elements. Similarly, do not make items appear clickable if they are not.
Make sure links do not look like decorations or ads.
Feature icons sparingly, and only when they have meaning.
When a graphic is associated with a link, make them both clickable
Provide breadcrumbs and other navigational cues to orient users to the rest of the site.
Make sure the back button works.
Create navigation by icon, button or link
Icon needs to be nicely organized
Design a user-friendly and aesthetic looks (suggestion).
Create a search function (suggestion).

Optimize site performance. A half-second delay could result in a notable downward shift in user satisfaction (in this study, YouTube is used as the platform to published video content).
Utilize either embedded or stream video.
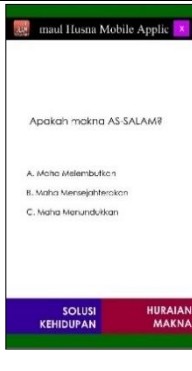Embed sound with audio control.
Apply adult voice.
Use cartoons/Illustrations

FIGURE 2. The Proposed Interaction Model

PROTOTYPE DEVELOPMENT

In this study, prototype design and development are regulated by the Alessi and Trollip Instructional Design Model. This research serves as a guideline in the design and construction of mobile applications. This model is chosen because it boasts flexibility and can be fashioned to suit needs, working style, philosophy, and environment (Alessi & Trollip, 2001). According to the proposed model, the prototype has been successfully developed and go to the next stage, the testing part. The model has been applied and implemented in the development of AHMA-SP. The signalling principles and Nielsen's design guidelines have been used in specific mobile apps interfaces, as shown in Table 3.

TABLE 3. Application of Interaction Model in AHMA-SP Prototype

ASMAUL HUSNA ... MASUK	Flashing button, this button uses the Picture-based technique, the use of a button with indications that it is clickable with a flashing signal.	Asmaul Husn — ASMAUL HUSNA / HURAIAN MAKNA / SOLUSI KEHIDUPAN / KUIZ KEFAHAMAN	The main title is animated into the apps, which depict the text-based concept for titles and headlines.

	The main menu buttons are shown using an animated hand icon to depicts the picture-based signal to show that the buttons are clickable. The buttons are shadowed to make them stand out.		• Section for "Huraian Makna" or the meaning for each of the 99 names. The hand icon shows the names individually to show that they can be clicked for more information. • Then page number is also highlighted to ensure that the user realised that they are on the page 1 list of the 99 names. Each page contains ten names. • There are also arrows indicating that the user can click to go to the next page or previous page.
	One of the 99 names' meanings and the text-based signal is applied to highlight the meaning and essential keywords.		Colour-coded is used in this page to signify the sections of the page. The tabs are divided into three different colours to differentiate the parts.
	In this content page for "Solusi Kehidupan", an Audio-based technique is used where voice intonation is accompanied by written text.		The main keyword is written in capital letters to highlight the question in the quizzes section.
	• Match interaction design familiar standards. • Choose familiar navigation schemes.		Feature images with simple backgrounds to keep the focus on the picture.

	• Offer a reasonable number of choices. Too many options can deter people from making the correct decisions or from deciding at all. • Feature category that indicates where they lead. • Organise content by meaningful categories.		• Indicate clickable elements. • Similarly, do not make items appear clickable if they are not.
	• Integrate videos with the related content. • Feature clear indicators to help users identify video content. • Use videos to show emotion or concepts that cannot be conveyed as well in writing. • Integrate videos with the related content.		• Featuring a few fancy components can increase appeal but consider the most straightforward solution first. • Provide navigational cues to orient users to the rest of the app. • Make sure the back button works.
	• Limit the use of jargon. • Minimise redundancy. • Format text for readability. • Avoid playing sound automatically, and provide easy-to-use audio controls.		• Attract with clean, simplistic designs and ample white space (visual gaps). • Reinforcing accomplishment with rewards.

USER TESTING

The user test is classified into a quantitative category, using a quasi-experimental approach using factorial pre-test and post-test design (Randolph, 2008). Both control and treatment groups encounter a specific set of mobile applications that aimed to improve their understanding of the context they selected. This experiment is performed in two phases: (i) pilot study; and (ii) actual research.

Before the actual research, a pilot study is conducted to validate research procedures, tools, gather feedback from learners on the mobile app for improvement, and expose the shortcomings in the experiments' design or the proposed method. Thirty-five students have participated in the pilot research sessions at selected universities, and these students are not involved in the actual study. The overall result shows significant improvement in understanding the content through the pre-test and post-test that have been carried out. The sample is chosen using an appropriate sampling method for quantitative analysis, and the minimally acceptable sample size is usually 30 participants (Brown & Green, 2016; Cohen & Swerdlik, 2009; Gay, Mills, & Airasian, 2012; Randolph, 2008).

The actual research is conducted involving 177 students. This study is conducted at three Universities in northern Malaysia to obtain homogeneous sampling. University students

are equivalent regardless of demographic aspects and possess the same abilities in the area tested (Brown & Green, 2016; Cohen & Swerdlik, 2009). Every university in each region is randomly allocated to various mobile applications to curb the possibility of data sharing between a diverse group of participants. The facilitator had notified the participants before the session and introduced them to the mobile app. During the same week, students participated in experimental research but with different group schedules. This session is held in a lecture hall, classrooms, and computer labs, and the duration of treatment is about an hour.

DISCUSSION

Knowledge could be defined as a belief which agrees with the facts. It is also defined as facts, information, and skills acquired through experience or education, the theoretical or practical understanding of a subject known as awareness or familiarity gained by experience of a fact or situation (Merriam-Webster Dictionary, 2017; Oxford Dictionary, 2020). In this study, knowledge refers to learner's knowledge of Asmaul Husna, their meaning, and the benefits of practising them. It is measured using a knowledge awareness instrument called Asmaul Husna Knowledge and Awareness Instrument (AHKAI), designed by the researcher based on the guideline from Bradburn, Sudman, & Wansink (2004).

From the experiments that have been conducted, it is noteworthy that there has been a remarkable improvement in Asmaul Husna knowledge among university students, as shown in Table 4. Significant differences were obtained from the following experiments and demonstrated the successful use of Signalling principles and Nielsen's design guidelines in the developed mobile application. Their level of understanding and memory is enhanced for the meaning of the Names based on the Pre-test and Post-test results depicted in the table.

TABLE 4. Descriptive Statistics for Pre-Test and Post-Test for Knowledge Score

Group		Pre-Test	Post-Test
Control	N	88	88
	Mean	6.6136	8.0455
	Std. Deviation	1.77746	2.06174
	Std. Error of Mean	0.18948	0.21978
Treatment	N	89	89
	Mean	4.9888	8.3933
	Std. Deviation	1.53367	1.26687
	Std. Error of Mean	0.16257	0.13429
Total	N	177	177
	Mean	5.7966	8.2203
	Std. Deviation	1.84434	1.71293
	Std. Error of Mean	0.13863	0.12875

ANCOVA was also conducted to see whether there is a significant difference in knowledge between the control and treatment group participants. Results obtained are summarised in Table 5. The p-value is shown to be 0.000, which is under 0.05. Hence this result is significant. There is a substantial difference between the treatment and control group

participants in the knowledge score. Therefore, these results explain that participants in the treatment group received higher scores on their knowledge than those in the control group.

TABLE 5. ANCOVA Analysis for Knowledge Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	161.090[a]	2	80.545	39.443	0.000
Intercept	320.816	1	320.816	157.105	0.000
PreTest	155.737	1	155.737	76.265	0.000
Group	57.583	1	57.583	28.199	0.000
Error	355.317	174	2.042		
Total	12477.000	177			
Corrected Total	516.407	176			

a. R Squared = .312 (Adjusted R Squared = .304)

Nevertheless, there are still a few things to keep in mind about this newly developed model. After the prototype was assembled based on the introduced model, some suggestions and problems could be ascertained from the experts met, for example, misunderstandings on the use of shadow for a button. According to experts, the shadow should only be used on overlap information, such as it has to be placed in the text area. Only the use of shadow in the text territory is necessary to make the button more visible.

Likewise, in the user's opinion, with the use of background colours, they prefer the use of coloured backgrounds, but it is contrary to Nielsen's principle that colour and white space in the text space are more important. So, there is some disagreement between Nielsen's suggestions and the user requirement.

Also, Signalling's principle suggests that the text is animated to attract attention, but experts say it can sometimes disturb the user's concentration due to repeated movement. It can cause users to feel confused and disturbed by the animation's movement, disrupting the learning process.

All these ideas and suggestions have been taken into consideration and should be adapted in the future.

CONCLUSION

This mobile learning guide should help produce more quality mobile learning content, a better mobile learning experience, and an excellent mobile learning environment for the community's benefit. This research would significantly contribute to the body of knowledge, Human-Computer Interaction, Interaction Design, Mobile Application, Signalling principle, and Nielsen's design guidelines. A mobile application will contribute to the body of knowledge and, thus, its implications. It will reveal mobile learning's advent towards bridging theory to practice, mainly in Islamic mobile applications. The design and development envisaged will help future multimedia developers design and construct better Islamic mobile learning applications, particularly in Muslim education. On the other hand, it

will also provide an overview of the Android operating system's eligibility to support a multimedia's learning environment. In conclusion, the study results also showed that the mobile app that uses both principles' hybridisation had increased students' knowledge of Asmaul Husna instead of the mobile app that does not use the principles. This research, therefore, supports the advantage of hybridising the Signalling principles and Nielsen design guidelines.

ACKNOWLEDGEMENT

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