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Investigation of the Effects of Various Navigation Patterns in the Design of Mobile Learning Applications within Saudi Higher Education

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ABSTRACT

The aim of the present study is to investigate the effects of different navigation patterns for mobile learning (m-learning) application designs, on students' academic performance and skills development in the IT department of Albaha University, Saudi Arabia. Pre- and post-achievement tests to assess knowledge of theoretical concepts for online-learning application design and a pre-/post-observation card to measure the participants' skills were considered as a useful supplement. Thus, design-based research was conducted, using an experimental approach to examine students in their third year of a Platform-Based Development (PBD) course: a compulsory module in the University's IT department. Sixty male students registered in this course were recruited as a convenience sample for the investigation and then divided into two groups. The first experimental group studied how to design m-learning applications using linear navigation, while the second experimental group took the same class, but used net (grid) navigation. The findings indicate statistically significant differences between the mean scores of the first group (who used a linear navigation style), and the second group (who used a net [grid] navigation style), generating the p-values 0.03 and 0.01, respectively. This outcome was therefore in favor of the second group, who studied and applied a net navigation pattern; as shown in the results of the achievement test and observation card for m-learning application design skills. The findings suggest a need to train instructors intensively in how to simplify instruction in the design of smart phone learning applications.

1. Introduction

This current era is characterized by tremendous progress in the fields of enhanced learning technologies, communications technology, and m-learning applications [1,2]. Progress in these fields has posed many challenges to educational systems worldwide. This has demanded radical change and development through various technological innovations, in order to maximize their potential in the service of education and consequently enhance students' learning achievement [3]. Most segments of society have realized the importance of smartphones, such as those produced by iPhone, Galaxy, Huawei, etc. and are appealing for their use in sectors such as education [4].

The education sector has already been affected by curricula and courses run on device platforms, as encountered by most users with computer experience across the developed world. It should also be noted that if learning takes place with suitable technologies in the right environment and context, it can produce excellent results in many educational situations, particularly in terms of interaction and communication. Moreover, it effectively takes into account individual differences between learners [5,6]. This undoubtedly promotes the efficiency and quality of teaching and learning via the design of multiple e-learning applications for smart devices [7]. In the relevant context, [8] assert that ICT has led to the production of educational mobile applications, which have contributed to the development of teaching methods, and provided an opportunity to enhance instructional techniques that can promote an effective educational environment. In turn, this can help stimulate students' interest and motivation, as well as challenging them appropriately.

Multimedia educational software comprise one genre of educational application for smart devices, characterized by multiple image-processing on a single subject in various media, such as audio-content, still images, graphics, animation/video and text. This software is intended to enrich and diversify the processing of topics communicated via these applications [8,9]. M-learning applications of various types allow a learner to learn independently, without the need for in-depth knowledge of mobile-learning settings. Moreover, the use of mobile and educational applications is perhaps the most appropriate form of e-learning program for teaching certain kinds of scientific material [10,11]. [12] argues that there are five interactive functions of multimedia software that can prove useful when studying subjects: confirmation, self-pacing, navigation, inquiry, and elaboration. Therefore, this study aims to experimentally investigate navigation patterns for designing an interactive m-learning application.

2. Research Model and Hypotheses

The skills required to design smartphone applications for interactive self-learning are complex. Continuous and coherent practical training is therefore required to be able to design an integrated electronic application [13]. To be specific, undergraduate students are faced with the task of learning difficult skills on the Platform-Based Development (PBD) course, as these will be fundamental to them attaining competence in designing for the online computer and technology environment. As a specialist in this field at Albaha University in Saudi Arabia, the present researcher has noted distinct difficulties in teaching these skills in the design of educational smartphone applications, pointing to the need for innovative and unconventional methods, which will enable instructors to develop these skills in their students [14].

Much of the existing educational technology literature emphasizes that the potential of application design to solve many educational problems is dependent on increasing students' participation and interaction [15]. Therefore, the present research aims to investigate the impact of different navigation patterns on skills in m-learning application design, and on the learning outcomes and performance of students on a mandatory IT program for third-year students at Albaha University. This study therefore seeks to develop teaching strategies for the University's PBD course. These consist of new, useful and effective methods of enhancing learners' motivation and facilitating their mastery of general application design skills, and more specifically, for designing m-learning applications. In recent years, there has been an increasing interest in the use of various types of navigation in e-learning for the benefit of electronic education and training, as these help determine the suitability of each pattern for

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specific electronic content. This is what [16] refers to as the need to assess the type of interaction, its appropriate content, its importance, and its impact on the development of average skill performance and knowledge acquisition. The design of m-learning applications requires a set of instructional procedures and plans to determine the learner's path and the conditions for transitioning from one unit of information to another [17].

E-learning programs consist of various types of navigation that enable learning and interaction with the tools provided. Interactivity is an effective component of e-learning applications, as it connects all elements of the content according to the specific navigation involved. Navigation styles in the design of e-learning applications include linear and net navigation [15]. A learning application with specific content that a student must study, together with related activities and questions, calls for linear navigation [18]. Therefore, the system/application has full control and the student cannot choose to omit any steps from the content. Conversely, net navigation is more complex and consists of multiple links, leading the learner in different directions, particularly when the application has a vast array of content [19]. Control lies with the learner in this type of navigation, as he or she can select preferred sequences of content.

Therefore, this current research aims to measure the impact of different navigation styles (linear and net) applied in the construction of e-learning on the enhancement of learning skills amongst IT students at Albaha University. The main hypotheses of this study are as follows:

H1: There are no statistically significant differences at the level α=0.05 between the mean scores of the first group of IT students, who undertake a unit on m-learning application design using a linear navigation style, and the mean scores of the second Group, who undertake the same unit using a net (grid) navigation style, when the results of an achievement test on theoretical concepts of m-learning application design are compared.

H2: There are no statistically significant differences at the level α=0.05 between the mean scores of the first Group of IT students, who undertake a unit on the m-learning application design using a linear navigation style, and the mean scores of the second group, who undertake the same unit using a net (grid) navigation style, when the results of a skills performance observation card are compared, revealing the students' m-learning application design skills.

3. Research Methods

This study explores approaches to designing an e-learning application based on different navigation styles (linear and net), with a view to enhancing Web and e-learning application design skills. This was achieved by investigating differences in the effectiveness of each style with an achievement test and skills development observation card. The findings of this investigation are expected to confirm which modern methods offer optimal time saving and resource investment, as well as enhancing communication and interaction between learners and the e-learning environment. Accordingly, an experimental research approach was adopted as the most appropriate means of meeting this research objective. Using this approach, the navigation styles for designing online learning applications were examined and the findings compared with similar studies in the extant literature. Moreover, a pre- and post-module observation card method was implemented to evaluate the learners' skills in designing an online interactive learning application. Furthermore, pre- and post-achievement tests were conducted to assess the learners' knowledge, acquired in practice while designing the application via either of the two navigation styles.

4. The Research Sample

This current research was carried out at Albaha University, a public university in Saudi Arabia. It is one of Saudi Arabia's most supportive and enthusiastic universities for the use of e-learning and distance learning to complement traditional learning approaches. Accordingly, there is a compulsory PBD module taught in its IT department. Once the students have completed this module, they are expected to be able to create online and mobile applications. However, the researcher noted the difficulties experienced by students registered on this module in Semester 1, 2019-2020. As a consequence, and in view of the manageable number and availability of this cohort, they were selected as the target sample in this research. The sample therefore consisted of 60 male third-year undergraduate students, selected in a convenience sampling approach.

5. Development of the Instruments

At the beginning of the experiment, a brief description of the main objectives was presented to the targeted sample to ensure their informed consent, and to confirm that their data would be dealt with confidentially and used solely for the research purposes. Moreover, although the module was mandatory for their course, it was explained that they were free to request their withdrawal from this current study at any time before the data analysis, without compromising their academic grades. They would then continue the module without being observed or taking the pre- and post-achievement tests, whereupon any of their data relating to this experiment would be securely destroyed. The sample was split into two Experimental Groups: A and B, with 30 students in each. Group (A) was assigned to design a learning application using a linear navigation style and Group (B) were assigned to design a similar learning application using a net navigation style. Table 1 illustrates the study's experimental design.

Table 1: Experimental study design.

Tools / Groups	Pre-evaluation	Experimental process	Post-evaluation
Group A	Observation card	Design using a linear approach	Observation card
Group B	Achievement test	Design using a net approach	Achievement test

The observation card was adapted slightly from previous studies to meet the main research objectives here. It comprised 40 items, formulated so that the observer could measure the learners' skills while they were designing the application. The items consisted of multiple-choice questions, using a three-point Likert scale that ranged across 1 (Students have no skills), 2 (Students have some of the necessary skills) and 3 (Students have all the required skills).

Conversely, an achievement test was prepared to evaluate the participants' knowledge, including their knowledge retention, understanding and implementation of electronic application design. This test comprised eight 35-part questions, designed to gather both qualitative and quantitative data. Moreover, the test began with a number of demographic questions to collect personal information about the participants, so that some data on their background could be provided. In addition, instructions and guidelines on how to answer these questions were clarified for the participants beforehand.

6. Data Collection Procedure

Both quantitative and qualitative data were subsequently collected in a pre- and post-achievement test using a three-point Likert scale observation card. Pre-assessment (with the observation card and achievement test) was conducted for the two Experimental Groups and the data were processed in preparation for statistical analysis. This pre-evaluation confirmed that the two groups were identical in their level of design skill and knowledge relating to the module. Group (A) then began designing the electronic application using a linear style, while group (B) used a net (grid) style. Meanwhile, the observers concentrated on the participants' implementation and scored their efforts with the observation card. Lastly, the participants were required to retake the same achievement test, so that the results for their knowledge could be compared, before and after the test.

The post-intervention scores for both the observation card and achievement test were entered into an Excel sheet in preparation for statistical analysis, as covered in the next section.

7. Data Analysis

The data collected in this research were analyzed using SPSS software. Statistical methods help a researcher to map mathematical expression relating to the research objectives. To ensure that there was no bias in the outcomes towards either the first group, taught how to design an m-learning application in a linear style, or the second group, taught the same class using a net (grid) style, the hypotheses were tested statistically; based on the participants' scores in the pre-achievement exam and on the design skills pre-observation card completed by the observers. An independent sample t-test technique was used to compare the average scores from each Group (A and B) to give the P-value. The next section presents the findings from this analysis.

8. Results and Discussion

The results of validating the data collection tools in the pre-experimental data revealed no statistically significant differences between the averages of the two Groups: Group A designing an m-learning application in a linear style, and group B undertaking the same task in a net (grid) style, resulting in P-value = 0.71. Table 2, below, presents the statistical findings for the mean, standard deviation, t-test, and p-value differences between the two groups in the pre-achievement test.

Table 2: Pre-achievement test.

Tools / Groups	Participants	Mean	Std. Error	t-Test	Sig.
Group A	30	2.70	1.09	2.47	0.71
Group B	30	2.62	1.39		

Table 2 shows that there are no differences between the two sets of results obtained from the pre-experimental data (Groups A and B), comparing the groups' achievement test scores. It is therefore likely that initially, all participants in both groups A and B were identical in terms of their knowledge, understanding and recall of theoretical concepts and skills for designing the m-learning application, as illustrated in **Fig.1.**

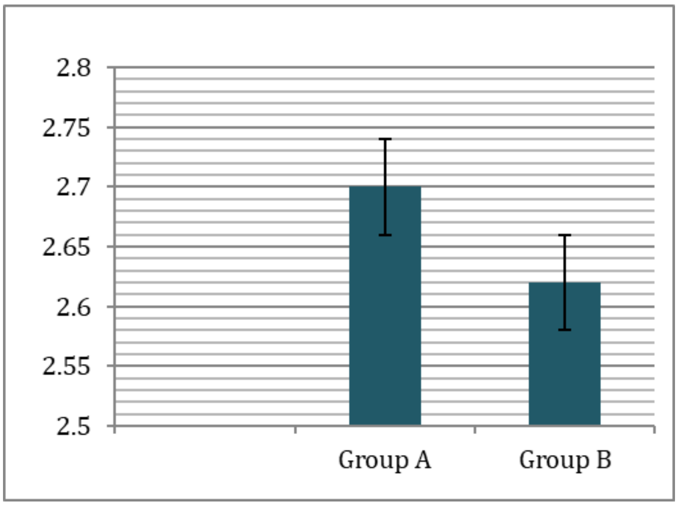

Figure 1: Mean difference between the pre achievement tests

Conversely, the findings from the observation card were also tested to validate the card's implementation for both groups. The pre-observation cards were therefore analyzed, revealing no statistically significant differences between Groups A and B in terms of the participants' skills in designing m-learning applications (P-value = 0.32). Table 3, below, presents the statistical findings for the mean, standard deviation, t-test, and p-value differences between the two Groups for the observation card data. These results confirm the validity of the observation card used in this research.

Table 3: Pre-observation card.

Tools / Groups	Participants	Mean	Std. Error	t-Test	Sig.
Group A	30	10.8	5.72	0.33	0.32
Group B	30	11.2	6.89		

Table 3 illustrates that in the results obtained from the pre-experimental data, there are no differences between the two Groups when comparing the scores from the observation cards. It is therefore likely that initially, all participants in Groups A and B were identical in terms of their m-learning application design skills, as shown in **Fig.2.**

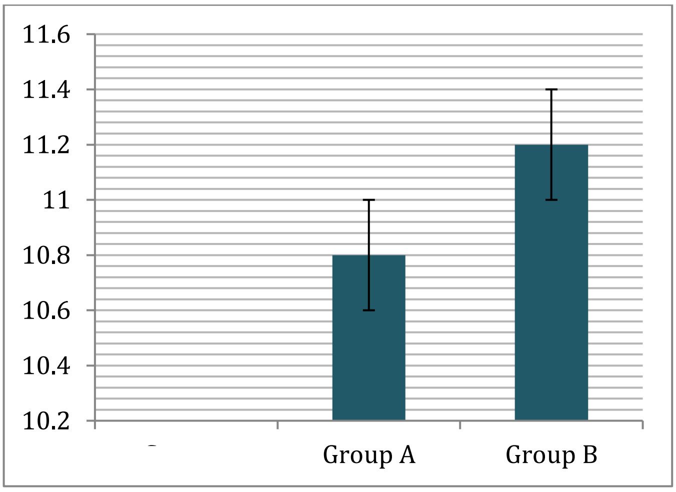

Figure 2: Mean differences for the pre-observation card

In this research, the validity of both the achievement test questions and observation items was confirmed. The results of the hypotheses tests will now be presented in the next section.

Result of the First Hypothesis (H1):

H1 states that there are no statistically significant differences at the level of significance (α=0.05) between the mean score of Group (A) – who undertook the m-learning application design module using a linear navigation style – and the mean score of Group (B) – who took the same module using a net (grid) navigation style – in the post-achievement test on theoretical concepts and skills for designing m-learning applications. An independent sample t-test technique was applied to compare the means of Groups A and B. Table 4, below, presents the results for H1, relating to the participants' post-achievement test scores.

Table 4: Post-achievement test.

Tools / Groups	Participants	Mean	Std. Error	t-Test	Sig.
Group A	30	25.86	5.42	2.03	0.03
Group B	30	28.65	5.49		

As Table 4 shows, H1 is rejected, as there is a significant difference between the two Groups: P-value = 0.03 in the participants' post-achievement test, in favor of students learning to design an m-learning application with net (grid) navigation. **Fig.3** demonstrates the mean differences between the two Experimental Groups in the post-achievement test on theoretical concepts and knowledge of designing an online learning application.

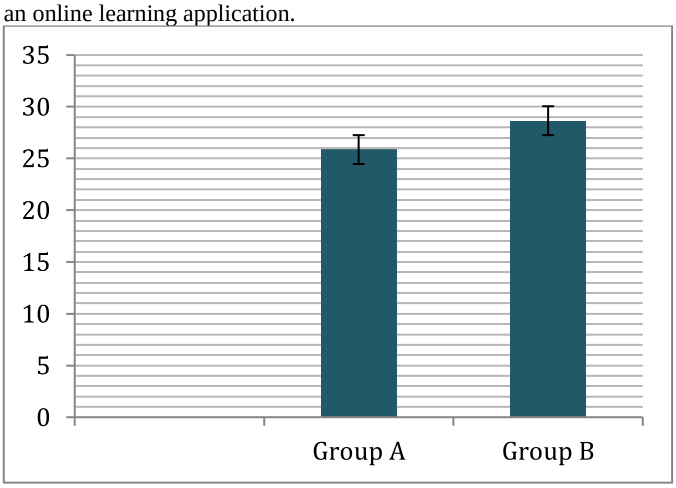

Figure 3: Mean differences for the post-achievement test

Results for the Second Hypothesis (H2):

H2 states that there are no statistically significant differences at the level of significance (α=0.05) between the mean score of the first Group (A), undertaking the m-learning application design unit with a linear navigation style, and the mean score of the second Group (B), undertaking the same unit with a net (grid) navigation style, measured using a skills performance post-observation card for the IT students' m-learning application design skills. An independent sample t-test technique was applied to compare means between the two Experimental Groups. Table 5 presents the results for H2 in terms of the participants' observation card scores.

Table 5: Post-intervention observation card.

Tools / Groups	Participants	Mean	Std. Error	t-test	Sig
Group A	30	56.56	6.82	2.85	0.01
Group B	30	65.55	8.83		

As Table 5 shows, H2 is rejected, as there is a significant difference between the two Groups, with P-value = 0.01; found using a post-intervention observation card to assess the participants. The observation found in favor of students learning to design an m-learning application using net (grid) navigation. **Fig.4** demonstrates the mean differences between the two Experimental Groups in the post-intervention observation card, completed by the observers for the participants' skills in designing an online learning application.

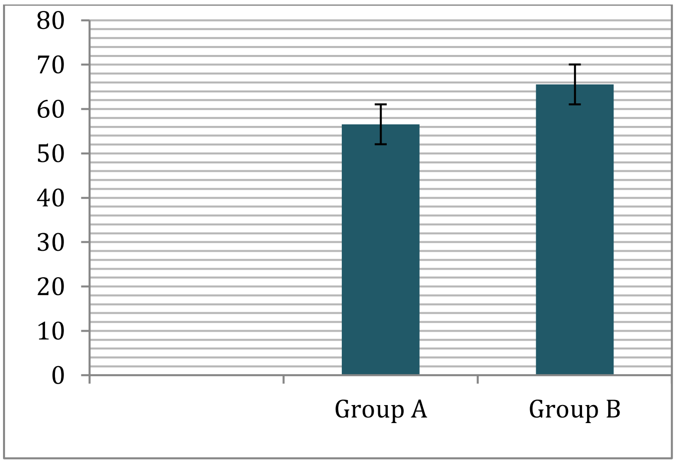

Figure 4: Mean difference for the post-intervention observation card

The most obvious finding to emerge from this study is that designing online learning applications via net (grid) navigation provides learners with broad scope for accessing and engaging deeply with learning content. It is possible that this approach assisted the IT students in increasing their skill in m-learning application design. The finding is consistent with those of previous studies, such as [20], who examined the effectiveness of different navigation patterns and their attractiveness. The above study generated similar results, with the learning achievements of students using net navigation being statistically higher than those of students using linear navigation, because the former appeared to feel free to navigate and learn without constraints. These findings enhance our understanding of multimedia use (video, image, audio- and text), since the use of grid navigation for designing interactive online learning applications has been proven to have a significant effect on learners' test performance and skills development.

It has also been shown that designing m-learning applications based on instant feedback for the learner clearly mitigate learners' weaknesses and capitalize on their strengths. In contrast, [21] demonstrated that the attitude of students using linear navigation was positive towards controlling and monitoring learning from the initial steps until the final screen, leading to optimal outcomes.

9. Conclusion

The present study was designed to determine the effect of different navigation patterns of m-learning application design on students' academic performance, and to explore ways of developing students' design skills. The contribution of this study is evident, as the outcomes point to enormous potential for informing practitioners, researchers and instructors in higher education. The findings provide evidence that general awareness amongst these stakeholders of the importance of various types of navigation, especially net (grid) navigation, is highly recommended. Therefore, instructors need to design their lessons in an interactive way and provide different multimedia to enhance the learning and ensure that learners obtain real benefits in their learning performance. Additionally, higher education can exploit the advantages of this type of navigation (grid) to improving the delivery learning process.

Future research should therefore concentrate on investigating the design of various classes of student on different navigation styles, and other different universities based on the culture may provide more reliable results to be generalized. However, considerably more workshops and instructor-training courses should be undertaken to establish best practice in the design of m-learning applications. Moreover, students should be provided with practical training in particular learning design to reduce difficulties that they might face when undertaking the (PBD) course. In sum, the present study findings and accurate evaluation of the impact of m-learning in Saudi Arabia will help enhance policy making and the effectiveness of m-learning pedagogies for higher education.

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