Effects of Screen Size in Mobile Learning Over Time

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ABSTRACT

Two experiments were conducted in order to investigate the effects of screen-size (3.5" vs. 7" vs. 10.1") on efficiency of mobile learning (m-learning) over time (immediate vs. delayed). Experiment 1 (N=141) revealed that students who took a mobile learning course on a large screen scored higher on a test administered immediately after the completion of the course. In Experiment 2 (N=111), another test was conducted two months after the first test. The Result indicated that the screen size did not make a significant difference on m-learning students over time. In detailed, test scores of students who took the course on a small screen were not relatively affected by the time of administering the test, whereas test scores of students with a large screen mobile device were decreased over time. Implications of notable findings are discussed. Also, limitations and future studies are examined.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in interaction design**; **Mobile devices**; • **Applied computing** → *Computer games*;

KEYWORDS

screen-size, mobile learning, m-learning, delayed effects

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1 INTRODUCTION

With rapidly growing mobile technologies, students have used mobile devices such as tablet personal computers or smartphones for reading text, watching movies or studying [3]. In addition, these technologies make that many users of mobile devices enable to see and create online contents via the devices. This trend suggested new education environments which make students receive education services in anywhere and anytime. In particular, this ubiquitous type of learning services and systems, which is called mobile learning (m-learning,) provides considerably nice benefits for undergraduate students [6].

Although m-learning has been studied as a communication device of the new era in the academic society and a large number of previous studies examined important visual effects of multimedia in education and learning, few studies have focused on the effects of different screen sizes on m-learning [13]. For example, does information delivered in small or large screen have different effects on m-learning students? A large number of studies showed that the screen size is one of the most important factors to the successful circumstances of efficient learning [16]. In addition, a study conducted by Knoche and colleagues found that the user's perceived quality of viewing experience is crucially determined by the screen size [11]. As another example, a viewer's semantic process of visual perception was crucially associated with the screen size in watching television on a mobile device [11, 22]. Additionally, previous studies showed that visual perception and attention functions of humans are crucially related to the screen size [2]. These cognitive functions make humans keep their visual information and build up an overall impression of the entire inputted sight [2]. However, there are few studies which aimed to analyze the effects of the screen size on m-learning students.

In addition to the effects of the screen size, the measure of time is a significant factor affecting the efficiency of m-learning students. However, few experiments were conducted to analyze the effects of the screen size and a time lapse on m-learning students. Therefore, the current study aims to discuss both two points as follows.

2 LITERATURE REVIEW

2.1 Screen Size

Mobile devices such as smartphones and tablet personal computers have been widely used for learning via online owing to extended mobility and portability. In wide fields, screen size of devices differently affected on performance of tasks. Specially, screen size significantly affects educational performance and learning [13]. Also, previous studies related to users' psychology indicated that a larger screen size evoked greater presence, enjoyment and better recall-memory for users than a smaller screen size [4]. Although

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these studies were conducted via fixed screens, their findings suggested that the size of screen may affect the psychology of users. Similar with these findings, the screen size may have different impacts on using mobile devices because there are other factors which can significantly affect the psychology of mobile device users [10].

Although users simply think that smaller screen elicits better mobility than large screen, there are other issues in mobile devices. First, the larger screen size was used, the better viewing quality and comfort-ability were served. Second, more detailed tasks can be conducted. For instance, when a person does paint drawing tasks via a larger screen, the pointing-accuracy and performance should be better than those via a smaller screen.

Related to educative situation, a study by Kim and Kim [9] found that large screen was more efficient on learning second language vocabulary than small screen by conducting a post-test and retention test. Therefore, this study is interested in the role of screen size in mobile devices and its effects during m-learning.

2.2 Immediate and Delayed Effects

Generally, studies on immediate and delayed memory have been conducted in advertisements which are designed to deliver specific contents visually and auditorily [15]. A study conducted by Fazio, Sanbonmatsu, Powell and Kardes [5] found that the recorded memory on particular contents was changed over time. The results of the experiments indicated that effects of positive or negative feeling of students in delayed moment are more mitigated than those in the initial moment. This tendency is generally explained by two psychological effects of sleeper effect and normal decay. The sleeper effect is referred as "*a phenomenon that an initial impression from particular contents can be influenced and changed by different media characteristics (e.g. motion vs. still pictures) as time goes on*" [22]. The normal decay is referred as "*a phenomenon that effects of media characteristics on persuasion or attitude toward particular contents are disappeared as time goes on*" [22]. In other words, effects of media characteristics on attitude toward particular contents have been increased over time in the sleeper effect, while those have been decreased over time in the normal decay. As one of the most representative examples of the normal decay, Sung and Cho [22] showed that there are notable changes in users' perceptions of particular advertisements between initial moment and delayed moment. In detailed, they found that more dynamic visual materials can immediately lead to higher degrees of attitudes toward particular contents, while this effect was disappeared in delayed moments.

The current study expected that there are notable different effects of m-learning between initial and delayed moments. In addition, we can expect that the more dynamic visual materials may appear dissimilar immediate and delayed effect on learning educative materials. In other words, students with large screen-equipped mobile devices may be more efficient on delivering the education knowledge when those with small screen at initial time, the effects of large screen will be reduced or removed over time.

3 EXPERIMENT 1: IMMEDIATE EFFECTS

Experiment 1 investigated whether variations in screen size would influence participants' performance of a test on M-Learning course materials they watched on mobile devices with different screen size as well as their satisfaction with and attitude toward these devices.

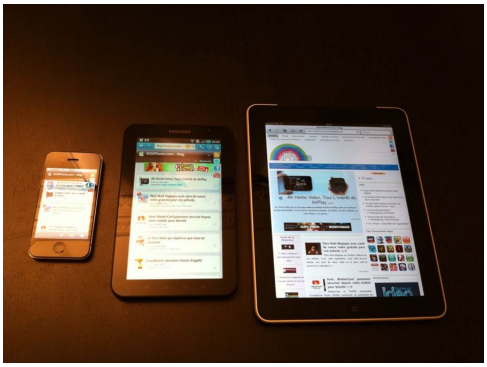

Figure 1: Mobile devices used in the experiment.

3.1 Method

3.1.1 Design and Participants. A between-subjects experiment was conducted with three conditions representing three levels of screen sizes (3.5" vs. 7.0" vs. 10.1"). 141 students (69 males, 72 females) enrolled in an introductory communication course at a large private university in Seoul, Korea volunteered for the experiment. Participants ranged in age from 19 to 30 years, with a mean age of 24.7 years (SD=2.10). All participants reported that they had prior experience with using mobile devices, including smartphones and tablet computers, but they had little knowledge of and unfamiliar with the M-learning contents used in the current experiment.

3.1.2 Design and Participants. The experimenter initially chose and downloaded six 60-minute long undergraduate course videos from the university's online course database. 10 graduate students then watched the videos and rated the neutralness of the contents of each video. These students were familiar with all these videos because they had taken and watched the selected videos while they were undergraduate students at the university. Based on this pretest, a course video about European history and marketing management was rated as having the most neutral content (4.0 on a 7-point scale) and selected as the stimulus material for the experiment.

Replicating the experimental procedure adopted in studies conducted by Kim and Gilman [8] and Kim and Kim [9], three mobile devices with 3.5" screen, 7.0" screen, and 10.1" screen were prepared, and each device played the selected video in 320×240, 480×320, and 800×600 resolution, respectively (Figure 1). Different resolutions were prepared because research has found that playing videos in the same resolution on different screen sizes affects how users perceive and evaluate the video contents [12]. The experimenter asked two video-rendering companies to encode and compress the video in the most suitable resolutions for the three different screen sizes.

3.1.3 Procedure. The experiment was conducted with three participants at each session. Upon arrival at the laboratory, participants were asked to sign an informed consent form and randomly assigned to one of the three mobile devices. Participants were seated in three separate rooms so that they were not able to see the mobile devices assigned to the other participant. They were told that they

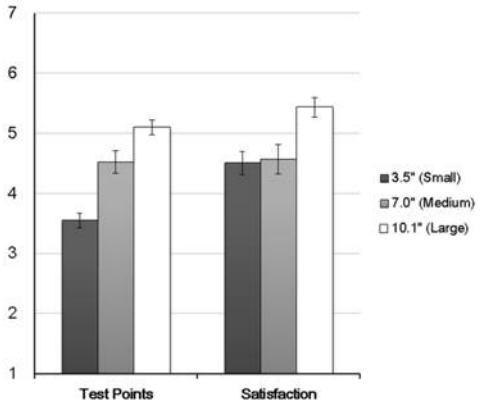

Figure 2: Means and standard errors of the test scores and perceived satisfaction.

were going to watch a 60-minute long course video about European history for the next five days (i.e., 60-minute per day for five consecutive days). The experimenter then started the video and left the room after starting the video. This procedure was repeated during the remaining experiment sessions.

At the end of the last session on the fifth day, participants were asked to take a test consists of 14 questions on the materials they learned for the past five days. Each question was worth 0.5 point. In addition to the test, participants completed a post-experiment questionnaire (7-point Likert scales ranging from 1="strongly disagree" to 7="strongly agree") measuring their satisfaction with the course (Cronbach's α=.88) and attitude toward the course (α=.91). The questionnaire items were adopted from validated prior studies [17, 18].

3.2 Results

A series of analyses of variance was conducted to examine the effects of screen size on the dependent measures. Results showed that participants who used the 10.1" screen (M=5.10, SD=0.86) scored higher on the test than those with the 7.0" (M=4.52, SD=1.30) and 3.5" (M=3.55, SD=.87) screens, F(2, 138)=27.15, p<0.001. In addition, participants who used the 10.1" screen (M=5.43, SD=1.10) experienced greater satisfaction with the course than those used the 7.0" (M= 4.57, SD= 1.65) and 3.5" (M= 4.51, SD= 1.32) screens, F(2, 138)=6.73, p<0.01 (Figure 2). Screen size of the mobile devices, however, had no effect on participants' attitude (p=.69).

4 EXPERIMENT 2: OVER TIME EFFECTS

While the results from Experiment 1 revealed that participants with the largest screen scored higher on the test and experienced greater satisfaction with the device, the goal of Experiment 2 was aimed at exploring whether this effect of screen size in M-learning would be sustained when another test was administered two months after the first test.

4.1 Method

111 participants (average age=24.55, SD=2.09) revisited the laboratory two months after the last class, and took another test consists

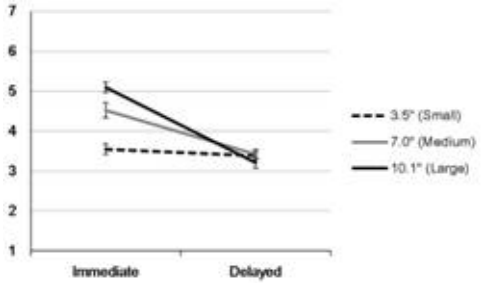

Figure 3: Interaction between screen size and time of administering the test predicting performance on the test.

of 14 questions about the course video they watched on the mobile devices. Although the questions in this test were different from that of the earlier test taken two months ago, a pretest revealed that the level of difficulty of Test 1 (M=6.9) and Test 2 (M=6.7) was roughly identical.

4.2 Results

A mixed repeated-measures ANOVA with time of administering the tests as a within-subjects factor and screen size as a between-subjects factor was conducted. Results from the RM-ANOVA revealed significant effects of time of administering the test, such that the score of Test 1 (M=4.39, SD=1.21) was higher than Test 2 (M=3.34, SD=0.82), F(1, 108)=87.872, p<.001. However, time of administration had no effects on participants' satisfaction with and attitude toward the course. In addition, screen size did not have significant effects on the test performance as well as satisfaction with and attitude toward the course.

As shown in Figure 2, interaction between screen size and time of administering the test was significant, F(2, 108)=19.651, p<0.001. Effects of screen size on test performance significantly decreased over time for participants with the 7.0" and 10.1" screens. For participants with the 3.5" screen, however, time of administering the test made no difference to their performance on the test.

In addition, screen size had significant effects on the test-scores in total. Participants who used the 10.1" (M=4.16, SD=1.31) and 7.0" (M=3.97, SD=1.22) screen scored higher on the test than those with the 3.5" (M=3.47, SD=.77) screen, F(2, 108)=13.997, p<.001. However, the screen size did not have significant effects on the score of Test 2, p=0.44.

5 DISCUSSION AND CONCLUSION

In Experiment 1, we examined the immediate effects of mobile learning so that the results and findings were used in two different aspects. First, the results can be used to investigate the effects of screen size on psychology and learning of students. As shown in the results of Experiment 1, screen size was highly related to the test score and the perceived satisfaction of m-learning. It was not surprising, for a large number of previous studies already indicated that the larger screen was used, the better results we could meet [14]. Therefore, the results of Experiment 1 were consistent with the results of the prior studies. Second, the results can be used as a baseline to examine and evaluate the delayed effects of m-learning in Experiment 2. By comparing the results of Experiment

1 and Experiment 2, we could see that the influence of screen size maintained or disappeared.

In Experiment 2, the effect of screen size was disappeared. Although there was no significant difference in Test 2, participants who used the 10.1" showed the worst result in the three groups (Figure 2). Therefore, the effects of screen size on m-learning students were declined over time. In detailed, there was no difference from the effects of screen size after two months from m-learning.

As shown in Experiment 1, screen size has differential impacts on knowledge level and satisfaction of students. Large screen size has the highest effect to accumulate knowledge in the class of mobile learning. However, the effect of screen size disappeared over time as shown in Experiment 2. Relatively, the effects of large and medium screen size (10.1" and 7.0") were rapidly dropped, while the effect of small screen size (3.5") was maintained. Similar with previous studies, the finding of this study is consistent which larger screen size is more effective for providing mobile learning than smaller screen size. For instance, a study by Kim and Kim indicated that large screen size was more effective to learn English vocabulary than small screen size regardless of media presentation types [9].

Also, the gap between immediate test-result and delayed test-result was explained by the heuristic-systematic processing theory. When students use a large screen, they should see relatively large visual information. Regarding immediate educative knowledge, the students could process semantic processing. Therefore, more dynamic and larger visual effects may remain. After two months, however, the impacts of large screen declined rapidly, since the students processed and tried to use their knowledge information in a semantic and cognitive way. In contrast, the impacts of small screen declined rather slowly on the knowledge of students, because the students cognitively processed and derived their knowledge from the material. The two different processes can be explained by heuristic processing. Sung and Cho [22] indicated that humans tend to think and understand dynamic materials more independently and heuristically than they do static material. Because this heuristic processing for dynamic material needs more dominant use of cognitive resources than that for static material, heuristically semantic processing is very difficult to remain in students' knowledge [1, 23]. Therefore, the effects of cognitive processing remained as their knowledge. Sung and Cho [22] showed that the patterns between dynamic and static materials were reversed on the attitude toward mobile advertisements over time.

Another possible explanation for this pattern is the Multiple Resource theory and Limited-Capacity Information Processing theory [21]. These two theories indicated that dynamic and multiple visual impacts and modalities may occur cognitive overload. Therefore, while more dynamic and bigger information were delivered via larger screen size, it may trigger that students perceived the mobile device with smaller screen size as easier and more concentrated to use for mobile learning.

Prior studies found that effects of multiple modalities of videos, which include dynamic information, change over time when they represent phenomena [7]. These findings may represent one of the alternative ways to help m-learning developers and providers offer more successful services for students. In particular, because m-learning videos with large screen are more efficient in the short term, we should consider various ways to maintain this improved result as long as possible. There are few potential methods to maintain: systematic points such as multimodalities [7], contents (e.g. mobile games [19]), and design improvements [20].

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