The Effect that Screen Size has on Video-Based M-Learning.

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Abstract

This paper focuses on using m-learning to teach university students. It reports on an empirical investigation that studied the effect that screen-size has on video-based m-learning. The results suggest that screen sizes typical of a PDA device may facilitate more effective learning, in comparison to screen sizes typical of a mobile telephone. The implications of this finding for the design of m-learning environments are discussed.

1. Introduction

"The widespread use of mobile phones [and other mobile devices] enables a long awaited dream: learning at any place, at any time." [1, p.307]. This highly ubiquitous form of learning, termed mobile or m-learning, may benefit university students in particular [2][3].

The success of m-learning depends on mobile device ownership [4]. Mobile devices include devices such as mobile telephones, ‘smartphones’ and personal digital assistants (PDA). Recent surveys of large numbers of students (1100+) across a range of countries (Italy, Bulgaria and Japan) found that virtually all students owned a mobile telephone [5][6]. However, the same surveys found that only 20% of students owned a PDA.

This raises an interesting issue. The screen size of a mobile telephone is typically small, in comparison to that of a PDA. It has been suggested that screen size is critical to the success of effective m-learning [7][8]. This suggestion is supported by empirical work that demonstrated screen size can affect the general usability of a mobile device, for example [9][10][11]. However, no work has specifically investigated the affect that screen size has on learning per se.

Screen size may be especially limiting for m-learning environments that rely heavily on detailed video clips. Therefore, to explore the effectiveness of using a video-based m-learning environment to teach university students, it is necessary to empirically investigate the effect that screen size has on learning. The study reported in this paper is the first step towards addressing this issue.

2. Empirical study

A between-participants design was used. Thus, each participant was randomly allocated to one of three conditions; ‘small screen’ (Nokia 6600 mobile telephone, screen size = 42mm diagonal), ‘medium screen’ (Motorola E1000 mobile telephone, screen size = 58mm diagonal) and ‘large screen’ (Compaq iPAQ H3800 PDA, screen size = 96mm diagonal). These conditions were based on the three categories of mobile device screen size proposed by Weiss [12].

The study was carried out in a café on a University Campus. The café was a busy and noisy environment; similar to where a m-learning application may typically be used. A total of 45 participants, who were all students, took part. Their average age was 24, which ranged from 18 to 58 years old.

Each participant completed part 1 of the study, which focused on their subjective opinion, and then completed part 2, which tested their objective performance.

Figure 1. Screen shot from the “how to measure blood pressure” video.
2.1 Part 1: Subjective opinion

To explore the effect that screen size has on students’ subjective opinion of m-learning, each participant watched an educational 5 minute video (about industrial economics) on their allocated device. The video clip was of equal quality (both audio and visual) and equivalent resolution on all three devices.

After watching the video, participants completed a questionnaire. The questionnaire contained 9 questions, to which they responded to on a 5 point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Uncertain, 4 = Agree, 5 = Strongly Agree).

<table>
<thead>
<tr>
<th>Question</th>
<th>Large screen</th>
<th>Medium screen</th>
<th>Small screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. This form of communication could increase access to learning.</td>
<td>3.80</td>
<td>4.20</td>
<td>3.67</td>
</tr>
<tr>
<td>Q2. This form of communication could increase the quality of my learning.</td>
<td>3.40</td>
<td>3.40</td>
<td>3.13</td>
</tr>
<tr>
<td>Q3. I wouldn’t mind carrying the mobile device</td>
<td>3.70</td>
<td>3.67</td>
<td>3.60</td>
</tr>
<tr>
<td>Q4. Watching the video on the mobile device was fun.</td>
<td>3.70</td>
<td>3.73</td>
<td>3.27</td>
</tr>
<tr>
<td>Q5. I would recommend ‘mobile learning’</td>
<td>3.60</td>
<td>3.73</td>
<td>3.30</td>
</tr>
<tr>
<td>Q6. The screen was bright enough.</td>
<td>4.80</td>
<td>4.73</td>
<td>4.26</td>
</tr>
<tr>
<td>Q7. The screen size was large enough.</td>
<td>4.40</td>
<td>3.93</td>
<td>3.00</td>
</tr>
<tr>
<td>Q8. The overall picture quality was good enough.</td>
<td>4.20</td>
<td>3.73</td>
<td>2.40</td>
</tr>
<tr>
<td>Q9. The content of the video was clearly visible.</td>
<td>4.00</td>
<td>3.66</td>
<td>2.60</td>
</tr>
</tbody>
</table>

Table 1. Subjective opinion results.

The results were analyzed using a one-way between participants MANOVA. A MANOVA essentially conducts multiple ANOVA tests simultaneously in a single analysis whilst taking into account the number of tests, and hence minimizes the probability of a Type I error occurring [13].

Questions 1 to 5 focused on the participants’ overall opinion of mobile learning. No significant main effect was found for any of these questions; question 1 (F(1,43)= 2.62, p=0.09), question 2 (F(1,43)= 0.55, p=0.58), question 3 (F(1,43)=0.03, p=0.97), question 4 (F(1,43)=1.59, p=0.22) and question 5 (F(1,43)=0.94, p=0.40). This suggests that increasing the screen size (up to 96mm diagonal) will not significantly affect a student’s subjective opinion of video-based m-learning. Interestingly, for questions 1 to 5, in all three conditions the participants’ responses were on average above 3 (Table 1). This indicates a tendency to respond favourably to the questions, and hence this indicates that overall participants had a positive attitude towards m-learning.

Questions 6 to 9 focused on the participants’ opinion of the screen quality. No significant main effect was found for question 6 (F(1,43)=2.63, p=0.08). However, significant main effects were found for question 7 (F(1,43)=9.27, p<0.001), question 8 (F(1,43)=20.41, p<0.001), and question 9 (F(1,43)=10.89, p<0.001). Thus, to determine which device was responsible, Tukey HSD post-hoc tests were conducted. The pattern was identical for all three questions. The ‘large screen’ device was rated significantly higher than the ‘small screen’ device (question 7 - p<0.001, question 8 - p<0.001, question 9 - p<0.001).

Similarly, the ‘medium screen’ device was rated significantly higher than the ‘small screen’ device (question 7 - p<0.05, question 8 - p<0.001, question 9 - p<0.001). However, the ratings of the ‘large screen’ and the ‘medium screen’ devices were not significantly different from one another (question 7 – p=0.35, question 8 – p=0.26, question 9 – p=0.54). Furthermore, in the ‘large screen’ and the ‘medium screen’ conditions, the participants’ responses tended to be positive (i.e. above 3)(Table 1). However, the participants’ responses in the ‘small screen’ condition were not entirely positive. Specifically, participants did not find the overall quality or visibility of the screen to be sufficient (questions 8 and 9). Taken together, this indicates that reducing the screen size of a m-learning environment can have a significant detrimental effect on a person’s overall subjective opinion of its screen quality. And, if the screen size is small (around 42mm diagonal), then people may not regard the device to be sufficient.
### 2.2 Part 2: Objective performance

In contrast to part 1, part 2 of the study investigated the effect that screen size had on objective learning performance.

Each participant watched another 5 minute video about “how to measure blood pressure” on their allocated device (Figure 1). Again, the video clip was of equal quality (both audio and visual) and equivalent resolution on all three devices.

Before watching the video, participants were asked 4 questions to assess their prior knowledge of this area. Then after watching the video, they were asked the same 4 questions again to assess what they had learnt.

Conducting within-participants t-tests to compare between the ‘before’ and ‘after’ results (Table 2) found a significant difference for all three devices; ‘small screen’ (t(15)=-3.66, p<0.01), ‘medium screen’ (t(15)=-9.16, p<0.001) and ‘large screen’ (t(15)=-7.30, p<0.001). This shows that all three devices had a significant impact on learning.

<table>
<thead>
<tr>
<th></th>
<th>Small screen</th>
<th>Medium Screen</th>
<th>Large Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>0.53</td>
<td>0.20</td>
<td>0.27</td>
</tr>
<tr>
<td>After</td>
<td>1.40</td>
<td>2.20</td>
<td>2.13</td>
</tr>
<tr>
<td>Amount learnt</td>
<td>0.87</td>
<td>2.00</td>
<td>1.86</td>
</tr>
</tbody>
</table>

Table 2. Objective performance results (average number of questions answered correctly).

However, this does not address the key issue; whether screen size affects the amount of information learnt. This can only be determined by conducting a one-way ANOVA on the amount learnt in the three conditions (i.e. the difference between the ‘before’ and ‘after’ results)(Table 2). A significant main effect was found (F(1,43)= 6.8, p<0.01). Therefore, Tukey HSD tests were conducted to determine which device was responsible. It was found that participants using the ‘large screen’ device learnt significantly more than participants using the ‘small screen’ device (p<0.05). Similarly, participants using the ‘medium screen’ device learnt significantly more than participants using the ‘small screen’ device (p<0.01). However, there was no significant difference in the amount learnt between the participants using the ‘large screen’ device and those using the ‘medium screen’ device (p=0.91).

Taken together, this suggests that screen sizes of approximately 58mm (diagonal) and above can result in a significantly higher amount of information learnt, compared to screen sizes of around 42mm (diagonal) and below.

### 3 Discussion and conclusion

Regardless of the screen size of the mobile device, participants tended to have a positive overall opinion of m-learning (Section 2.1 – questions 1 to 5) and watching the video significantly increased their knowledge of the subject area (Section 2.2). However, some important differences were noted.

Compared to participants who used the mobile devices with the ‘medium’ and ‘large’ screen, participants who used the device with the ‘small screen’ had a significantly lower subjective opinion of the screen quality (Section 2.1 – questions 7 to 9) and learnt a significantly lower amount (Section 2.2). This may be because people tend to pay more attention when viewing a larger screen display [14]. However, the results of the participants who used the ‘medium’ and ‘large’ screen were not significantly different from each other.

Taken together, these findings indicate that if an m-learning environment that relies heavily on video-based material is displayed on a device with a small screen (42mm diagonal), such as an average mobile telephone, then the effectiveness of the learning experience may be inhibited. The importance of this finding is clear when one considers that a mobile telephone is the one handheld device that the majority of students own, and relatively fewer students own large-screen handheld devices, such as a PDA (Section 1). Furthermore, a recent user study found that there are practical reasons, such as portability, why students may actually prefer to use a small device for m-learning [15].

It is therefore important to consider how this issue could be avoided. One option is to use animations instead of video clips. As Ferwerda notes, a ‘functional’ representation, such as a line drawing or animation, provide a more direct way of conveying the fundamental aspects of an object or process, in comparison to using a photograph or a video [16]. Indeed, previous work has shown that students can learn effectively from animations presented in an m-learning environment [17].

An alternative option may be to employ ‘perceptually adaptive’ graphics techniques. For example, a video could be adapted based on a model of the characteristics of objects that humans...
have a natural tendency to focus on, such as peoples’ faces [18].

Whilst the study reported in this paper found an interesting and coherent pattern of results, further work is needed. In particular, work is needed to investigate the effect that screen size has when the video clip is incorporated into an interactive m-learning environment.

4. References


