Using Mobile Devices as Activity Aids in a History Museum

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ABSTRACT

Informal learning at museums and cultural heritage sites are an important complement to formal school learning. Children arriving on field trips or on a visit with their parents can expand their knowledge, and gain new understanding and perspectives of real world phenomena. Electronic mobile applications are often used in museums to provide information about the exhibits, as well as support student's engagement with the museum items. However, it is unclear whether they support learning better than conventional non-technological aids. Furthermore, it is unclear what type of electronic guide best supports learning. In this work, we examine young students' mobile learning in the museum, comparing three types of activity guides: a paper booklet, an information-based mobile application and a constructivist-based mobile application. Initial results indicate that students using the constructivist guide learned better than students using the informative guide but not better than ones using the paper booklet, and that overall, students preferred the mobile application over the paper booklet.

KEYWORDS

Mobile learning, Museum mobile guide, Handheld device

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1 INTRODUCTION

Informal learning in museums and other cultural heritage sites is a popular way to complement formal school learning by deepening and expanding school knowledge, relating to and presenting authentic objects, providing concrete ways for the assimilation of complex concepts, and promoting individuals' ability to observe and understand world phenomena [2, 5]. Museum learning is fundamentally different in several aspects from formal learning: being for a short time duration, requiring no continuity, and being primarily based on curiosity, intrinsic motivation, selection and self-control [1]. Museum learning occurs through interactions involving personal, socio-cultural, and physical contexts over time, [7].

One way to enhance student's engagement in humanity-oriented museums (as opposed to the more interactive type science museums) is by using electronic mobile devices. Mobile devices can provide customized and personalized learning experiences, building on user's own understandings and support their making of their own choices at their own pace [16]. At the museum, mobile technologies pose an opportunity and can provide museum visitors with a wide variety of novel and important services. The visitor can receive personalized adaptive information from a vast amount of content sources that can suit his or her needs at a particular time. Information can be tailored according to the visitor's learning abilities and preferences [1].

In order to understand if and how the use of mobile technologies can enhance informal learning at the museum, we first need to characterize existing mobile applications in such an environment. The integration of mobile devices as tools to support museums has become well established in recent years [6]. Many mobile museum guides, i.e., classical audio guides or more advanced multimedia guides, are ***information-based***, which means they have been designed to provide context-specific information presented in an information-centered way. Context is often achieved by utilizing location-based services [8], while information is mostly limited to audio, text, images or short video-presentations providing details on nearby exhibits [9–11]. While these kind of guides may be beneficial for an individual adult visitor, being able to provide relevant and sometimes personalized information and services, they may not be ideal for children or small groups. Children arriving to museums at school trips, or individually with their parents, often require a more engaging form of presentation, especially in humanity type museums. A different approach takes a ***constructivist-based*** direction that includes inquiry learning and problem solving. In this approach, visitors need to be more involved and actively produce their own interpretations. This is based on the epistemology that individuals are active learners and must construct knowledge for themselves [15]. A meaningful learning therefore, involves the granting of meaning to new acquired information by relating it to existing knowledge. Such a learning mode requires individuals' high engagement with meaningful tasks, while actively processing, interpreting and making sense of the information [17].

While there is a wide number of works introducing novel mobile applications aiming to enhance visitor experience and learning at the museum (either using the informative or the constructivist approach), very few works have actually shown that their mobile

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guide implementation improves learning over traditional ways. Furthermore, very few works have compared different design options for mobile guides, or compared how various designs of mobile guides affect learning. In this work, we take a comparison-based in-depth examination of how mobile guides can be used to support informal learning at the museum.

2 METHODOLOGY

In order to better understand the effectiveness and possibilities of mobile-based learning at the museum, we compared three activity-support tools given to students (7th and 8th grade) during a field trip at an archeological museum. Through observations and questionnaires, we examine and compare students' learning, engagement, and communication patterns, when using the following three main conditions: (1) Constructivist printed booklet (referred to as: ***paper***). (2) Informative mobile application (***informative***). (3) Constructivist mobile application (***constructivist***). The study uses a between-subject design, in which each student is assigned to one of the three experimental conditions.

2.1 Participants

The study included overall 128 students learning in 7th and 8th grade classrooms from two schools. In total we had 42 students in the paper condition, 42 students in the informative condition and 44 in the constructivist one. Students' ages (13-14 years old) assures children's sufficient skills to cope with the museums' texts and labels. Moreover, 7th grade children's awareness of the importance of dates is already developed and they can link dates with their own background knowledge regarding the period's events [3].

2.2 Study Procedure

The study was conducted at the Hecht museum, a small-to-medium sized archeological museum. It focused on two exhibition rooms: The ancient ship from Ma'agan Michael – a Phoenician ship, 2400 years old that was found and extracted from the sea, and the Galilea rebellion – an exhibition about the rebellion of the Jewish people against the Roman empire around 70AD.

When arriving to the museum, classes were divided into halves, each half with their teacher visited the museum on a separate day as a part of student's extra-curriculum activity for history learning. The students were further divided at the museum into two groups. Each group of students began the visit in one of the two exhibition rooms and moved to the second room after a short break. Since the study was a between-subject design, all students in each class used only one guide (paper, informative or constructivist). In the course of their visit of the two rooms students responded to the various tasks presented to them in their relevant guide and acquired the information from it while examining the different exhibits. After completing their visits of the two rooms, students performed a summary activity (on paper or tablets respectively) and completed a user experience questionnaire.

2.3 Material

We designed and developed three guides to support students' tour through the two exhibitions. All three guides involved the exact same information (including texts, images and same videos for the two digital guides). All guides led students through the museum, emphasizing students' direct engagement with the same exhibits and its labels. Time duration was predetermined for overall guide use (around 60 min.) and for each task separately, as evaluated according to its characteristics. Digital guides were implemented as a Web application and given to students on Lenovo 8" screen tablet computers.

Constructivist printed booklet. Students received a booklet containing printed text information with adjacent colored photos. They were asked to respond, using a pencil, to the various booklet constructivist-type tasks related to the different exhibits. The booklet for each exhibition included 24 pages.

Informative mobile application. Students used a mobile learning guide implemented on a tablet computer. The mobile guide included short videos (voicing the text information presented in the paper booklet) with adjacent written tasks. The design of these tasks was aimed at enhancing the recall and summation of the information. Tasks involved students' responses to a series of multiple-choice type questions with some open ones. The guide included approximately 15 screens for each exhibition.

Constructivist mobile application. Here as well, the students use a mobile learning guide on a tablet computer. They were presented with the identical set of short videos as the informative mobile guide. The constructivist tasks in this guide were thought provoking and identical to those presented in the paper guide, aiming to enhance students' integration of the new acquired information with their existing knowledge into a single coherent meaningful body of domain knowledge. The guide includes approximately 15 screens for each exhibition.

An important difference between the paper booklet and the mobile applications was in the way the information was presented. While in the two mobile applications, information was presented in the form of short audio-visual presentations that consisted of narrated text over changing images, in the paper booklet, images were printed adjacent to the written text. Another difference between the paper and the two mobile applications is the feedback. In the mobile application, we provided feedback on some of the closed questions (e.g. multiple choice, or questions asking to connect elements). This was done because providing feedback can enhance the learning process and is one of the advantages afforded by electronic guides.

The difference between the constructivist guide and the informative guide involved the tasks' pedagogical approach. The informative tasks focused on information ***recall*** of information presented in the videos or seen in the exhibits. Whereas, the constructivist tasks focused more on the ***assimilation*** of the information - granting it meaning - and the construction of new knowledge. To achieve these goals, tasks involved open ended questions that required students' composing of responses while applying prior knowledge, rather than choosing or signing a specific given answer.

2.4 Measures

2.4.1 User Experience. To measure student's experience and perceptions using the different aids, we use the UEQ questionnaire [12]. The UEQ questionnaire contains six scales with 26 items in total. The six scales examine the user experience in the following

dimensions: attractiveness, efficiency, perspicuity, dependability, stimulation and novelty.

2.4.2 Summary Activity. To measure student's learning, we asked students to complete a summary activity immediately after the completion of the learning activities in the two exhibition rooms. The questions focused on the modes of knowledge construction as it occurs based on the availability of different types of historical evidence (e.g., objects, visual or written reports), and research methods in the relevant domain, namely, history. It examined the acquisition of main principles of historical thinking such as, understanding cause and effect and the ability to understand historical deduction, for example, the ability to distinguish between organic and inorganic evidences and its meaning for their conservation over long periods. The activity included four sets of tasks, each set placed on one screen in the mobile applications or one to two pages in the paper booklet. Students' responses to the tasks were analyzed, and each set of tasks were rated according to a common scale and provided with a normalized score between 0-100.

3 RESULTS

We first present results of the learning outcome as was measured by the summary activity. This is followed by results of the user experience of the students as was measured by the UEQ questionnaire.

3.1 Summary Activity

We analyzed the results of the summary activity to see if there are significant differences for learning between the conditions. We removed from the analysis results of students who left three or more entire tasks unanswered, since no answering of so many questions is most likely an indicator of students who did not care to participate, rather than students not knowing the correct answers. After the removal, we were left with 40 students in the constructivist condition, 34 in the informative one, and 39 students in the paper condition. Figure 1 shows the results of the summary activity according to the four question sets. As can be seen in Figure 1, results indicate that students in the constructivist and the paper conditions performed better on tasks 1, 3 and 4, than students in the informative condition.

A one-way ANOVA on score was conducted to test the difference between the conditions. Results indicate a significant difference for Q3, $F(2,112)=5.67$, $p=0.004$, for Q4, $F(2,110)=3.75$, and for the total score, $F(2,114)=5.27$, $p=0.006$. Post-hoc analysis using the Bonferroni correction show that for both Q3 and Q4, as well as the total score, this difference stems from significant lower scores of the informative condition compared to both the paper and the constructivist conditions

3.2 Students' Experiences

Unfortunately, due to an error in data collection, one class in the paper condition did not fill in the user experience questionnaire. In addition, we removed data of students who did not fill at least 50% of the questionnaire. That left us with 42 students in the constructivist group, 38 in the informative and 25 in the paper group.

Results of the user experience questionnaire for the three conditions on the six UEQ scales are presented in Figure 2. When using a

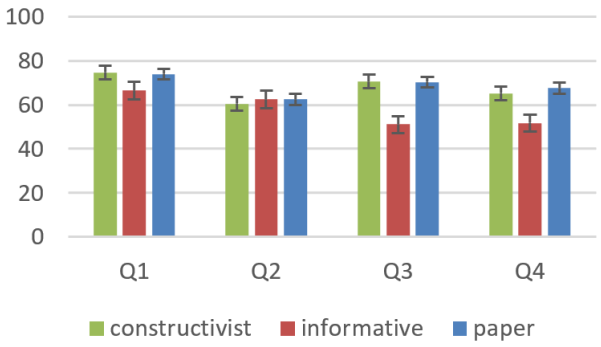

Figure 1: Summary activity results showing percentage of questions answered correctly using the three guides. Bars denote standard error.

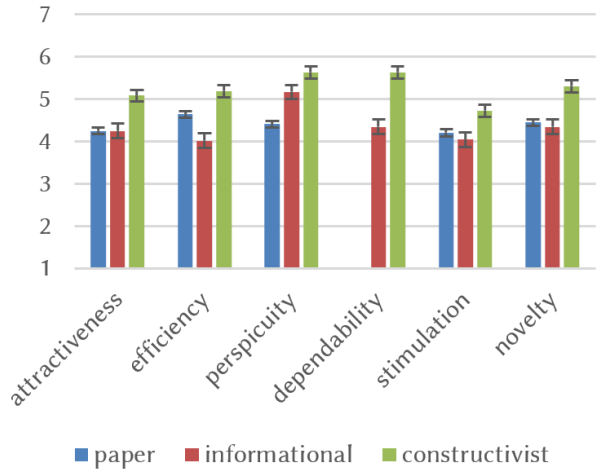

Figure 2: UX results according to the UEQ questionnaire categories in which a higher number means a higher rating for this measure (e.g., more novel). Because of an error in the data collection, no data was collected for dependability in the paper condition. Bars denote standard error.

Likert-scale type ordinal scale, it is recommended to employ a non-parametric test, therefore, we ran a Kruskal-Wallis test to examine difference between the three conditions, and a Mann-Whitney test with the Bonferroni correction for post-hoc comparisons. Results indicate a significant difference for attractiveness ($H(2)=9.56$, $p=0.008$), efficiency ($H(2)=11.8$, $p=0.003$), perspicuity ($H(2)=11.4$, $p=0.003$), dependability ($H(2)=13.27$, $p<0.001$) and novelty ($H(2)=8.7$, $p=0.013$). Table 1 summarizes the post-hoc tests.

Results show that the constructivist guide was rated highest on all scales. Specifically, it was significantly more attractive and more novel than the other two conditions and was perceived as more efficient and dependable than the paper condition. In general, the paper condition was found to be the same as the informative

	Kruskal-Wallis p-value	Paper -Inf p-value	Paper- Const p-value	Inf-Const p-value
Attractiveness	0.008	NS	0.012	0.009
Efficiency	0.003	NS	NS	0.001
Perspicuity	0.003	0.049	0.001	NS
Dependability	0.001	--	--	<0.001
Stimulation	NS	NS	NS	NS
Novelty	0.013	NS	0.033	0.007

Table 1: Statistical tests comparing between the three conditions on the 6 UEQ scales. P-values of the Kruskal-Wallis test which compare all three conditions are presented in the first column, followed by p-values of pair-wise comparisons done using the Mann-Whitney test. Significant results are colored in green..

condition, with the exception that paper was rated less on the perspicuity scale.

4 DISCUSSION AND CONCLUSION

Our results indicate that for learning, the constructivist approach was better than the informative one. That is, students using the constructivist booklet and the constructivist mobile application received significantly better marks on the summary activity compared to the informative application. This supports previous research on the benefits of constructivist learning [13] and shows they can be applied to a mobile learning environment. No differences were found between the paper and the mobile constructivist conditions, indicating that in this case, the technology did not affect learning.

When looking at the user experience questionnaires, we see that overall, students preferred the constructivist mobile application over both the informative application and the paper. Students rated the constructivist application as was more attractive, more efficient, more dependable and more novel than the informative one. However, the preference of the constructivist condition over the informative one is less clear, since from a design, utility and novelty point of view both guides were similar. One explanation can be that the constructivist guide was more engaging, causing students to think and discuss, which might have caused them to be better appreciative of the constructivist guide.

The user experience questionnaires suggest that students prefer the mobile application over the paper one. While students thought that the paper guide is easy to use, it seems that students prefer to consume information in an audio form rather than a textual format. In addition, students liked the novelty and the digital format of the mobile application. This is not surprising, as it is known that children today prefer digital media over books and text [4].

While the constructivist mobile application showed overall better performance over the paper guide, we did notice several advantages when using the paper booklet. When observing the students work, we noticed that using the booklets, students often looked back at previous information. This rarely happened with the mobile applications. Looking at the design of the mobile applications, a tablet screen is often too small for presenting all the required information. Its small size frequently determines the spatial organization of information pieces on the screen. This caused the location of information (e.g., text, short video, images, maps) to often be separated from the tasks relevant to them, challenging students' working memory resources, which are used for "holding" information sources together rather than on information processing, resulting in the multimedia "split attention effect" [14]. Furthermore, the digital application does not afford natural navigation between screens (i.e., it is possible to go back, however, users seldom go back to previous screens). Conversely, the paper guide affords students' easy examination of materials located in different pages for their processing.

To conclude, our initial results suggest that the constructivist approach was more effective in inducing learning than the informative approach. In addition, students preferred the constructivist guide over the informative one, showing it is possible to design an effective constructivist mobile tool for informal learning. Comparing the mobile to paper, learning outcomes were mostly similar. However, students preferred the mobile application over the paper one, supporting the hypothesis that students prefer the use of technology, and that technology can serve as a catalyst to mobile museum learning. Overall, the results suggest that museums and cultural heritage sites should invest in the design of constructivist mobile support tools for informal learning of students. We plan to further elaborate on our results with analysis of the student's video and audio recordings (to understand how learning actually took place).

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