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mLearn4web – A web-based framework to design and deploy cross-platform mobile applications

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ABSTRACT

This paper presents a web-based framework that allows the creation and deployment of mobile learning activities. We present an authoring tool that allows not-technically skilled persons to design mobile learning tasks and deploy them as a web-based mobile application. Since the presented approach is based exclusively on web-technologies, the deployed mobile application can be executed via a mobile browser and therefore is platform independent. Despite previous research efforts carried out in this domain, few of the projects have addressed this course of actions from a purely web-based perspective. Through the latest development of web technologies, mobile applications have access to internal sensors like camera, microphone and GPS and therefore allow data collection within web-applications. In order to validate whether the proposed framework can be applied in educational settings, we conducted a pilot study with experienced teachers and present the results of these efforts in this paper.

Categories and Subject Descriptors

D.2.11 [Software Engineering]: Software Architectures;
K.3.1 [Computers and Education]: Computer Uses in Education

General Terms

Theory, Experimentation

Keywords

Web-based framework, end-user programming, authoring tool, mobile learning, pilot study

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1. INTRODUCTION

The importance of integrating information and communication technologies (ICT) in the field of education is constantly increasing. In classrooms, a trend of a transition from traditional teaching methods to digital supported education can be identified [14]. Introducing the latest ICT developments in classroom settings can improve the quality of teaching [11]. If portable devices like modern mobile phones or laptop computers are used to support learning, those efforts can be referred to as "mobile learning" [13].

The continuous development of web and mobile technologies facilitates the creation of novel mobile applications, including those supporting mobile learning. Today's smartphones are equipped with a rich set of built-in sensors, e.g. positioning sensor, microphone and camera [9]. Recent developments in HTML5 enable access to those built-in sensors of mobile devices [6]. Thus, one way to avoid developing separate applications for each platform is to develop a web-application using HTML5 and JavaScript, which can be accessed via any web browser of every mobile device that supports HTML5, with the additional advantage of not needing to install supplementary applications on a device.

In order to integrate mobile technologies in the field of education, teachers need to be able to design and create mobile applications according to their own needs and requirements. Since they usually have neither the technical nor the programming skills to develop such applications, it is necessary to give them the possibility to easily author and deploy those on their own.

The remaining of the paper will present related research efforts in this field and motivate our work. Thereafter, we describe the implementation of two components of our proposed web-based framework: the authoring tool and the mobile application. We describe an initial pilot study as a first step of an evaluation plan and describe its outcome. Finally, we present our conclusions and future plans.

2. MOTIVATION AND RELATED WORK

As discussed above, one major challenge in the field of technology enhanced learning (TEL) is the possibility for end-users with no technical background to easily design and deploy their own mobile applications. Another major challenge is providing cross-platform mobile applications, which enables their execution of mobile applications without the concern of fragmented mobile devices available in the market. To tackle these two challenges, we present a web-based framework that allows easily designing, deploying and executing cross-platform mobile applications [16].

Despite previous research efforts conducted in this field, few of the projects have addressed the whole process chain starting from authoring or investigating it from a purely web-based perspective. Mulholland et al. [12] present with their nQuire project a way of designing learning tasks. However, they do not provide a possibility to deploy their learning scenarios automatically as a mobile application. Hwang et al. are lacking a way for teachers to author their own scenarios [7] and are not addressing the challenge of cross-platform development but only offering an Android application. The same applies for the LETS GO project [15] which provides an Android application to collect data and a web-based visualization environment for presenting the collected data but not an authoring environment. LETS GO does also not address the cross-platform development challenge. Giemza et al. offer in their LEMONADE project an authoring tool to deploy mobile applications [5]. However, LEMONADE only supports the Android Platform and thus is not tackling the cross-platform deployment issue mentioned above. Baloian et al. [1] argue that HTML5 has an enormous potential for executing learning scenarios with mobile devices. Nonetheless, they are focusing on learning scenarios but not on authoring, deployment or data-analysis. All these facts indicated that similar research in this area is conducted, nevertheless, no research project aims to offer consistent support starting from authoring and tackling the cross-platform issue at the same time.

This paper describes follow-up research to evaluate the work conducted in [17]. Based on our previous efforts, the challenges discussed above and also by identifying a gap in the combination of end-user programming and cross-platform development, we pose the following research questions:

- RQ 1: Is the web-based framework in [17] usable and acceptable for teachers?
- RQ 2: Which enhancements and new requirements can be gathered during a pilot study with experienced teachers?

3. MLEARN4WEB

To tackle the challenges mentioned above, we developed a web-based framework which makes it possible to design, deploy and execute mobile learning applications [16]. Users can design their own scenarios enabling them to execute these tasks on a mobile device. With the authoring environment, a teacher can select from various methods that enable adding content to a mobile application and using sensors of mobile devices.

As mentioned earlier in the previous section, there is a need to develop new tools that support mobile learning activities having in mind the latest developments related to ICT infrastructure in schools. In order to take full advantage of the available technological set-up, it is necessary to provide support for teachers to compose their own learning applications for those devices. Outdoor activities, of the kind of field trips, including phases such as data collection, documentation and observations are very well suited candidates for using mobile technologies as support. Krepel and DuVall [8] state that a learning activity outside the classroom, a field trip, can be divided in three phases: The pre-trip phase, where the preparation of a trip takes place, the trip itself and the post-trip phase, where the debriefing of the trip is conducted. Our proposed framework provides

technological support throughout all three phases by using a web-based approach, including an authoring tool to support the planning and designing of learning activities outside the classroom, the activity itself with a repository to store the collected data and a web-based visualization tool.

The web-based solution offers access to the tool from every computer with a modern web-browser installed and no installation of any additional software is needed. Furthermore, the mobile application is based on pure HTML5 and JavaScript in order to assure the compatibility to a wide range of modern mobile devices, offering access to the application with the mobile web-browser. Thus, no installation and updating of additional applications via an app store is necessary. A mobile web-application also guarantees compatibility to future mobile devices and operating systems. All these aspects have been carefully considered in order to make the adoption of technology easier for educators, as it affects the way teachers introduce new technologies into their everyday practices [2].

All three components of the framework, the authoring environment, the mobile application and the visualization tool are realized in pure HTML5 and JavaScript. As a backbone technology NodeJS is used. Since JavaScript is used as a key technology in every layer of the framework, all data is transferred as JSON objects. The MongoDB database accepts JSON objects as an input and therefore fits perfectly in the proposed design and is thus used for data persistence.

3.1 Authoring Tool

During exploratory observational studies with nine teachers we found that the majority of them envision the usage of ICT in combination with data collection scenarios. We are collaborating with those teachers that are part of a network of high schools in South East of Sweden. Fifteen out of twenty-two scenarios that were envisioned by the teachers were linked to data collection tasks, for instance measuring water quality at certain locations. Therefore, we are focussing on the designing of data collection tasks with the authoring tool.

The authoring tool allows designing multiple screens and each screen represents the data that is displayed on one mobile screen. Via "drag and drop" interactions, a user can add certain modules to a screen as well as remove them from the screen. These modules represent actions that can be executed with a mobile device. For instance, they allow to take pictures or videos. Each module has a description field where the author can add instructions to describe the learning task. It is also possible to rearrange the order of the modules on a screen. Because of the data collection purpose, currently the following modules are available: Textfield, Textarea, Numbers, Location, Picture, Video, Sound, Date and Multiple Choice. It is possible to mark certain input fields as required. If this mark is set, the users of the mobile application need to enter data here before they can submit their data. After designing a scenario, it is possible to save the scenario in a repository and it is automatically deployed as a mobile web application. The authoring environment also allows editing an already existing scenario.

3.2 Mobile Application

As discussed before, one challenge of designing mobile applications is the fragmentation of the mobile operating system market. A mobile application needs to be accessible by

a broad variety of users despite the huge market of different mobile devices and operating systems. To provide the look and feel of a native mobile application while using web technologies for the implementation, the JavaScript library jQuery Mobile is used.

After accessing the application via a web-browser of a mobile device, a list with scenarios, which were created using the previously described authoring tool, is presented to the user. Based on which scenario the user selects, the screens of the mobile application are built. On the first screen of the selected scenario, the information with the description is displayed. Following, each screen contains the previously designed tasks. At this point, a task can be to enter a text, a number or a date; taking an image or a video; recording sound or capturing the GPS coordinates. The latter could be done automatically for every action, however to make it more aware for the users, teachers and students, the geolocation data is only stored with a certain action. In the end, the user can submit the data to the server, where it will then be stored in the database. If a task was specified as "required" during the creation process of the scenario, it has to be accomplished to be able to submit data. The user can navigate between the different screens that were defined through the authoring tool by using either swipe gestures or the arrow buttons, which exist at the bottom of each screen.

4. PILOT STUDY RESULTS

In order to investigate the research questions posed before and to test whether the proposed framework can be applied to generate and deploy mobile applications in educational settings, we conducted a pilot study with experienced teachers invited by us to participate in a first pilot study. In total, 8 teachers took part in this study. After we provided a short introduction to the functionalities of the framework, the teachers were supposed to design a field trip and run a simulation of the designed field trip. The teachers were provided with computers and mobile devices. However, we encouraged them to use their own equipment since a major challenge for us is the cross-platform availability of the framework. For the designing process, MacBooks, Windows machines and Chromebooks were used. For the execution simulation different versions of iPhones as well as different versions of Android devices were used.

We gathered information about the experience with field trips and technical support to carry out these activities.¹ The fact that the teachers that took part in this study have in average 15 years of teaching experience partly eliminates the weakness of the small sample size.

Valuable information was also gathered during interviews that were conducted during and after the session. These interviews had the nature of an informal character and happened while offering support. We learned that the teachers consider field trips a valuable addition to traditional teaching methods and they would like to take advantage of the huge availability of mobile devices to support them. However, they do not have tools that allow them to easily include those scenarios in their teaching. This is also represented in the presented questions that were rated in 7-level Likert scale [10], where 1 was labeled "Agree" and 7 was labeled "Disagree". For calculations the reverse questions

were transformed accordingly. The initial questions about the usage of field trips within the teachers practices and the technical support of those show that field trips are a method that is used and accepted by the teachers but there is a lack of technical support for it. The average of the question, if the teachers value field trips, calculates to $M = 2.875$. This shows that field trips are considered a valuable contribution to traditional teaching methods. However, the questions about the usage of technical support during the preparation and execution of field trips did not show such good results. The average of support in the authoring process calculates to $M = 4.625$ and the average of taking advantage of mobile devices during the field trip is even lower with $M = 5.125$. To the question if tools that are used during the authoring process also offer support to the execution the average calculates to $M = 5.875$. In combination with the clear acceptance of field trips, as described above, and those results, it could be stated that there is a clear lack of a consistent technical support for field trips.

Following the general impressions about the teacher's experience towards field trips and their support, the participants were asked questions derived from Davis' Technology Acceptance Model (TAM) [4] to determine the Perceived Usefulness (PU) and Perceived Ease of Use (PEU). The questions were taken from Davis' et al. [3] and were altered to fit to our requirements. Each question was rated again in a 7-level Likert scale and reverse questions were transferred accordingly. Each participant had to answer the questions regarding the Perceived Ease of Use two times, once for the authoring tool and once for the mobile application. The reliability of the answers was tested by calculating the according Cronbach's Alpha. However, giving the low number of participants, the result of the Cronbach's Alpha would not provide reliable results, therefore we did not apply this method.

The overall average about the technology acceptance for the authoring tool calculates to $M = 2.239$ with a standard deviation of $SD = 1.188$. Since we defined the Likert scale with 1 as "Agree", this low average shows a high degree of acceptance. The average for the authoring tool calculates to $M = 2.508$ ($SD = 1.393$) where the average PU calculates to $M = 2.6$ ($SD = 1.51$) and the average PEU calculates to $M = 2.417$. For the mobile application the average calculates to $M = 1.969$ ($SD = 0.983$) where the average PU calculates to $M = 1.792$ ($SD = 0.8$) and the average PEU calculates to $M = 2.146$ ($SD = 1.167$). These low values indicate the high acceptance rate among teachers to design and execute mobile learning tasks and therefore provide an answer to the RQ1.

According to the results, the teachers had the biggest problems with the documentation. Here, the average values of $M = 3.75$ ($SD = 1.832$) for the authoring tool and $M = 3.25$ ($SD = 1.389$) for the mobile application show the dissatisfaction of the teachers with the documentation. However, the rest of the results show that they managed to design a scenario and simulate its execution. Thus, we value the results of the Perceived Ease of Use very high. Nonetheless, we are aware of the problem that we need to improve the documentation and the description of the available functionalities.

Discussions during the pilot study also revealed new requirements that the teacher have to the system. Furthermore, some expressions used in the system we developed

¹The complete questionnaire can be found here: <https://www.researchgate.net/publication/267210986>

are misleading and need further explanations. For instance, the difference between a "textfield" and a "textarea" is not clear to the teachers. Another issue was mentioned about the "numbers" field. Teachers were not aware of what this field does and where the difference between a text-input and a number-input is. Moreover, the teachers want more possibilities to customize the view during the creation process. For example, re-naming the screens in the screen list so they have a better overview of the content that is in a particular screen. Another major request the teachers posed is to add a collaboration feature. They expressed positive aspects of having a rating system of the scenarios. In that way it is possible to have a ranking of already existing scenarios and edit this one so they do not have to start from the beginning. In future iterations, we will consider to add this feature. During the discussion, the idea of introducing categories was also posed. In that way, it is easier to obtain a good overview of existing scenarios. This tackles the RQ2 and for future iterations of the system, these new requirements are very valuable and will be considered.

5. CONCLUSION AND FUTURE WORK

The previously described efforts are discussing only two components of the proposed framework. To conclude the framework we will also add a visualization tool that visualizes data that is collected during an execution of the designed learning tasks. This tool allows teachers and students to reflect over the actions during field trips.

While performing the pilot study, we were not satisfied with the performance of the mobile application. Despite taking advantage of new features that HTML5 offers to access internal sensors through a web browser, the performance was not matching native applications. That said, the teachers that were taking part in the study were not complaining or mentioning performance issues. For the purpose of our framework, performance is not a main concern but since we are introducing new technologies into the field of mobile learning, we are investigating possibilities in that area too. This is why, we are investigating other options to implement the mobile application. Right now, we are re-developing the application with AngularJS² in combination with the famo.us³ framework. In that way we are hoping to tackle the performance issue but also keeping the advantages of the web-based platform.

A crucial addition to the system that we will implement in future iterations is a collaboration system, thus one of the next step is the introduction of a rating system for the scenarios.

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²<https://angularjs.org/>

³<http://famo.us/>