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The (still) unused potential of mobile HTML5 in educational settings

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Abstract: The wide availability of mobile devices like smartphones and tablets among students as well as the included positioning technologies, high definition cameras and other sensors, together with continuous Internet access bring many new opportunities for developing mobile applications supporting learning activities. However, there is an immense fragmentation of operating systems for mobile devices. HTML5 is a promising approach to tackle this challenge. Mobile web applications run within browsers and nowadays, most mobile devices possess a browser that interprets HTML5. Nevertheless, the educational domain seems to ignore this potential and relies on the development of native applications. In this paper, we analyze the opportunities, advantages and drawbacks of developing mobile applications supporting learning activities with HTML5 compared with developing them natively. To illustrate our ideas, we present a couple of showcases that already rely on HTML5, which allow us to further review the development opportunities for mobile HTML5 applications in general, as well as specifically in educational settings.

Keywords: Mobile HTML5, mobile learning, mobile web development

1. Introduction

The importance of integrating information and communication technologies (ICT) in the field of education is increasing. In schools, a trend of digital supported education can be identified and studies show that introducing the latest developments of ICT in classroom environments can improve teaching methods (Milrad et al., 2013). Taking the mobility of learners into account and when they advantage of mobile technologies, we can refer to those activities as mobile learning activities (O'Malley et al., 2005). Furthermore, mobile technologies can facilitate learning outside traditional environments, such as classrooms, to enhance the learning experience (Farmer, Knapp, & Benton, 2007).

Especially modern mobile devices like smartphones and tablets can be utilized to support mobile learning tasks. High definition cameras, positioning technologies and other sensors, as well as ubiquitous Internet access became standard features. In spite of the multiple benefits that this setup offers, a major challenge for developers and researchers of mobile applications arises due to the huge fragmentation of mobile devices and their operating systems. Nowadays, the availability of mobile devices like smartphones or tablets is vast among students. Schools begin to recognize the potential that ICT can have in educational settings and even governments are starting to create policies to support ICT in teaching methods (The Swedish National Agency for Education (Skolverket), 2011). The often applied concept of using available devices in different settings is referred to as "bring your own device" and is especially interesting for the field of mobile learning (Ng, 2015). Therefore, it is important to offer cross-platform solutions.

Emerging web technologies, e.g. HTML5 and new JavaScript technologies, provide some of the solutions that can be used to address some of the challenges mentioned above (Xanthopoulos & Xinogalos, 2015). In recent versions of mobile operating systems, it is possible to access internal sensors of the device via a web browser. Our efforts are driven by the mentioned challenges and in this paper we discuss several approaches that serve as showcases for mobile HTML5. However, empirical results will not be discussed in this paper, since the mentioned approaches are serving as

proof of concepts. Therefore, the main research question explored in this paper can be formulated as following: *How can mobile HTML5 be beneficially utilized in educational settings?*

In the remaining of this paper, we will provide an overview of relevant work carried out in particular in the field of mobile learning. We will focus on the usage of HTML5 and JavaScript technologies in different projects and point out that they are still not recognized in the field of mobile learning. Thereafter, we will provide a general overview about the functionalities that mobile HTML5 offers, followed by a presentation of mobile HTML5 solutions to showcase the potential.

2. Related Work

Despite substantial research efforts conducted in mobile learning, only a few projects take advantage of mobile HTML5 and JavaScript characteristics and rely on native implementation solutions in their mobile component. In this section, we present an selection of relevant work and discuss their functionalities and, if applicable, their HTML5 and JavaScript usage. In this work, we are focusing on functionalities that mobile devices provide. Therefore, we are focusing on projects were internal sensors and data collection tasks are having a major role.

The Sensr project (Kim, Mankoff, & Paulos, 2013) is an effort that allows using web technologies to design a mobile application for data collection purposes. It is possible to use a web browser and well-known interaction methods like drag and drop to add widgets to a mobile app. Those widgets allow later to make use of the internal sensors of mobile devices to collect data like geolocation or taking pictures. After the authoring process is finished, all added information is then available as a configuration file for an iOS application.

The LETS GO (Vogel, Kurti, Milrad, Johansson, & Müller, 2014) project provides a mobile application with the purpose to collect environmental data to raise awareness of environmental issues and therefore uses internal sensors. A web-based visualization tool is then providing information about the data that is collected by the mobile application. Moreover, initial analytics are provided to be able to draw initial conclusions about the data.

Another approach to provide flexible mobile applications that make use of mobile specific components is the LEMONADE (Giemza, Bollen, & Hoppe, 2011) project. An authoring environment is available through a Java-based tool called FreeStyler. An Android application is designed to support field trips and collect location-based data throughout a trip. This data can then again be visualized and analyzed in the FreeStyler tool.

The nQuire (Sharples et al., 2015) project aims to support teachers to author, orchestrate and monitor inquiry-based learning activities. The web-based authoring environment allows designing and configuring scripted inquiry-based activities. This activity can then be supported by an Android application, which allows collecting data during the activity like

Project	Components	Usage of HTML5
Sensr (Kim et al., 2013)	Authoring, mobile	Authoring, visualization
LETS GO (Vogel et al., 2014)	Mobile, visualization	Visualization, 3rd party web-based environment for authoring
LEMONADE (Giemza et al., 2011)	Authoring, mobile, visualization	-
nQuire (Mulholland et al., 2012)	Authoring, mobile, visualization	Authoring, visualization

3. Motivation

Despite the opportunities of mobile HTML5 and JavaScript technologies, we have shown a number of mobile learning projects that include data collection do not take mobile HTML5 technologies into account. Especially in the educational field, the paradigm of “bring your own device” offers a huge potential due to the wide availability of mobile devices among students, but results in a variety of different devices utilized in the scenarios. This setup is highlighting the importance of cross-platform applications. Web solutions are a promising approach to tackle the vast fragmentation of the mobile device market.

Although Baloian et al. (2011) presented a work already in 2011 that discussed the potential that HTML5 has within the area of Technology Enhanced Learning (TEL) (Baloian, Frez, Diego, Jansen, & Zurita, 2011), we showed that the field still does not yet recognize this potential (sufficiently) regarding mobile HTML5.

By developing mobile web applications, it is possible to ensure continuous support for mobile devices. In previous updates of mobile operating systems, it occurred that vendors changed parts in their API and therefore certain functionalities needed to be re-implemented, which is not an issue while using web technologies. When it comes to updating an application, in web-based applications where we apply the Software as a Service (SaaS) pattern, it is only necessary to update the deployed application on the server and all users are using the latest version. Furthermore, if a new brand or operating system has a big impact and the current market pattern changes, it is safe to assume that HTML5 and JavaScript technologies will be supported. Additionally, due to the architectural characteristics of web applications, it is possible to easily integrate external web-based services or migrate to cloud-based environments. Moreover, existing tools allow to easily deploying web applications in terms of Continuous Integration.

We strongly believe that the mentioned features make the design of mobile applications with HTML5 and JavaScript a very fitting approach in the field of mobile learning. It offers a cross-platform solution while accessing internal sensors, which is a crucial requirement and can scope with fast evolving requirements. Therefore, this work discusses and highlights the potential of mobile HTML5 and JavaScript technologies in order to increase the awareness of the potential and discuss alternatives to native mobile application development.

4. HTML5 mobile support

As mentioned before, Baloian et al., (2011) discussed already the potential of HTML5 and their work serves as a foundation for this paper. However, the rapid development of HTML5 since 2011 increased the potential even more. The following aspects were discussed in the early work by Baloian et al.: Canvas, Web Database, Local Storage, File System, offline capabilities, Web Worker, semantic, WebGL, and Geolocation (the only mentioned sensor)

It is important to notice that the only relevant specifics for mobile devices are the geolocation and offline capability aspects. In the previous section about relevant related work (section 2), we identified that a general usage of HTML5 and JavaScript technologies among desktop components is already common. However, regarding mobile applications it is still not considered, therefore we are focusing on the aspects of mobile HTML5 and JavaScript support.

Since the discussed aspects by Baloian et al., (2011), HTML5 evolved immensely. Additional sensors are accessible via HTML5 and JavaScript, as well as other important aspects for mobile applications, like system-wide notifications, are now supported by HTML5 and JavaScript. Below, we present a list of the most important features already supported and also discuss existing drafts expected to be supported by mobile web browsers soon.

Sensors: Camera (Real-time QR-code scanning (only Firefox); Microphone; Accelerometer; Light Sensor; Magnetometer; Gyroscope; Proximity Sensor (only Firefox); Vibration; Battery Status

Additional features: Notifications (only supported by Chrome and Firefox); WebRTC; Web Speech API (only Safari and Chrome); Touch Events (Gestures)

It is important to notice that despite the development in HMTL5 and JavaScript technologies there are still challenges related to the usage of those technologies. Various functionalities mentioned in the list above are not supported yet by all modern mobile web-browsers or have a slightly different behavior within different browsers. Thus, a shift from the fragmentation of mobile devices to mobile browsers can be identified and is a challenge for web-developers that needs to be addressed. Nonetheless, we believe that HTML5 and JavaScript approaches are a valid option for cross-platform solutions. Furthermore, new standards for HTML5 are constantly developed by the World Wide Web Consortium (W3C) and multiple drafts of new functionalities are available. For instance, a draft for the support of NFC by HTML5 exists and is waiting to get supported by mobile browsers.

5. Software Engineering Aspects

The development of complex software systems based on platform independent technologies, demands for a high quality during the complete software development process. Especially with technologies like JavaScript that are not per se prominent for well-structured code. In order to achieve this, different technologies are available that provide different aspects of code quality assurance.

First of all, the code itself should be organized using frameworks that target towards a high code quality, e.g., by modularization of the code. A well-known framework in the area of platform independent JavaScript development is the AngularJS framework developed by Google. The resulting code should be organized in a central code repository, especially if more than one developer works on the code, but also for single developer projects in order to provide a base point for the Continuous Integration/Continuous Delivery framework. The major task here is to regularly check out the code from the central code repository, build it and run tests in order to ensure that only high quality versions of the software will finally be deployed. Usually, before deployment also quality checks directly on the code level are performed. Here, tools like *linting* or *Sonar Cube* are well accepted in the community and stand for high quality code checks. After all checks and quality gates are passed, the Continuous Integration/Continuous Delivery system directly deploys the code automatically to potentially Cloud Computing based systems, e.g., in a traditional IaaS/PaaS (Infrastructure/Platform as a Service) or a more modern container based way.

Next to general advantages of deploying IaaS/PaaS, like reduced costs, it is also a good solution to scope with fast evolving requirements like present in the field of mobile learning. In contrast to the multi-user, multi-installation deployment method, the multi-user, single installation deployment as in IaaS/PaaS can be adjusted easily. When new requirements occur and updates are necessary to match new requirements, only the one installation needs to be updated in order for all users to use the newest version. These methods also allow to easily deploy systems in cloud-based environment and therefore offers an easy solution regarding the scalability of a system. IaaS/PaaS solutions are usually proving methods to easily integrate external services or to easily integrate parts of the system into other solutions. A common element in those solutions is the availability of an API that eases the integration process.

To summarize, the mentioned software engineering aspects (Continuous Integration, Deployment as IaaS/PaaS and integration characteristics) are a fitting approach to design applications in the field of mobile learning to scope with the fast evolving and changing requirements.

6. Implementation Details

To provide evidence that mobile applications implemented with HTML5 and JavaScript technologies are sufficient to perform the desired activities, in particular data collection activities that involve using internal sensors of mobile devices, we present a variety of implementations that are build with HTML5 and JavaScript.

6.1 Proof of Concept

We designed an application that can access various internal features of mobile devices from within a mobile web browser. This application serves as a proof of concept to showcase the potential of HTML5 and JavaScript technologies and can be accessed at the following link: . It includes the following features: Taking pictures and videos; recording audio; getting the device orientation; detecting the device motion; detecting ambient light; using the microphone to perform speech-to-text processing; using the camera to scan QR codes; activating the vibration; getting the battery status; and measuring the proximity of obstacles in front of the mobile device. This highlights the potential of these technologies and at the same time serves as a test-platform to check for the support of mobile browsers. This showcase gives an imposing impression of the potential of mobile HTML5 and JavaScript technologies and proves that they are a viable alternative to native applications when it comes to access of internal sensors of mobile devices.

6.2 mLearn4web

mLearn4web is a framework implemented within the field of mobile learning that allows teachers to design and deploy mobile applications (Zbick, Nake, Jansen, & Milrad, 2014). Teachers do usually not posses the technical knowledge to take advantage of the technologies existing among students. Therefore, we developed a framework consisting of three components to support teachers to design their own mobile learning activities. The three components of this framework are: (1) an authoring tool; (2) a mobile application; and (3) a visualization tool. All components are realized with pure web technologies. This framework is designed to support learning activities in "bring your own devices" scenarios. The authoring tool allows teachers with simple and known interaction methods like drag and drop to design the content of a mobile application. With the help of this tool it is possible to design a big amount of learning activities supported by modern mobile devices.

The mobile applications designed by the authoring tool mentioned above are automatically deployed and available as mobile web application. As discussed before, by using web technologies it is also possible to use certain internal sensors of mobile devices in our case: the camera, the microphone, and the geolocation. The third component of mLearn4web is a visualization tool. All data collected by the students using the mobile application and relevant (meta) data are displayed in this tool. This tool is supposed to offer an initial analysis of the performed learning activities. Studies regarding the usability, technological acceptance, and learnability of the presented framework have been conducted (Zbick et al., 2014; Zbick, Nake, Jansen, & Milrad, 2015) and the results were positive. Especially the good result regarding the technological acceptance leads to the conclusion that using HTML5 and JavaScript technologies to provide mobile applications is a fitting approach also for the users.

6.3 Designing geo-collaborative application for "learning with patterns"

We have developed a prototype of a system (including a web-based authoring/visualization tool, as well as a mobile application based on HTML5 and JavaScript) to support geo-collaborative learning activities that include using sensors to collect data in order to find evidence of previously known patterns or identify new patterns. According to the specific scenario, the following functionalities for this system have been identified:

Creating Patterns: Creating a pattern consists on defining its name, goal, description, forces, etc. Students may also create patterns in order to document. Teachers can create patterns and tasks during classroom sessions, as they are presented to the students before the students start their tasks.

Creating Tasks*:* Teachers can create tasks consisting of instructions to be given to the students. Task creation involves defining a referencing geographic point or an area over the map. Students have to follow the path and find evidence of certain patterns in the designated points.

Assigning tasks to students*:* In the classroom and before leaving for the field activity, students turn on their mobile devices running the application.

Instantiating patterns*:* According to the proposed task, students may follow a certain path or explore an area of the city gathering data to collaboratively create instantiations of the pattern when they find a certain element that they think it corresponds to the pattern giving by the teacher. Instantiations consist of photographs or sketches of objects found which complies with the pattern definition.

Monitoring students' work: teachers can monitor the students' work in areas where Internet is available and a client-server communication is possible.

The system has been implemented and pre-tested by early users in an experiment with four subjects aged 22 to 24 aimed at evaluate the user interface. The task they were given was to find out which were the most common tree types in a certain park. For this experiment tablets were used. The activity lasted for 1.5 hours with a positive outcome.

7. Conclusions

In this paper, we discussed the potential for HTML5 and JavaScript technologies in the field of mobile learning. For mobile learning activities that often include data collection tasks, internal sensors and features of modern mobile devices like smartphones or tablets are a promising setup. We showed that web-technologies did get recognized when it comes to desktop applications like authoring environments and visualization tools. However, the mobile characteristics of HTML5 and JavaScript technologies are still not recognized when it comes to supporting mobile learning activities with mobile devices, and researchers and developers rely on native Android or iOS applications. We acknowledge the challenge that various features of mobile HTML5 are not yet supported by all mobile browsers. However, it is important to note that core functionalities to fulfill the requirements to perform mobile learning tasks, like accessing camera, audio, and geolocation, are supported by all modern mobile browsers. Therefore, we argue that it is a valid approach to replace native applications, especially since we showed how important it is to provide a platform independent solution. Moreover, HTML5 is a constantly evolving standard and it is safe to assume that more features will be supported by more mobile browsers in the soon. Therefore, we believe that mobile HTML5 and JavaScript technologies have a huge potential, especially in the field of mobile learning. Our presented projects and the proof of concepts are examples of taking advantages of the mentioned technologies and still satisfying the user's needs.

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