Design Guidelines for Sensor-based Mobile Learning Applications

Conference or Workshop Item

Design Guidelines for Sensor-based Mobile Learning Applications*

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ABSTRACT

We present five design guidelines that we have developed from issues identified during our usability evaluations in a sensor-based citizen inquiry project. These have been compiled from existing literature, and after receiving feedback on use of the mobile application from participants through forum comments and survey responses, statistical analysis of the sensor measurements, and the researchers' observation and reflection. These guidelines aim to assist Technology Enhanced Learning (TEL) researchers and teachers who develop, modify or use mobile apps for their projects and lessons.

CCS Concepts: •Human-centered computing → Human computer interaction (HCI) → HCI design and evaluation methods

KEYWORDS

Design; mobile learning; sensors; mobile applications; usability

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1. BACKGROUND

In crowdsourced projects, those who initiated them recruit help from a large network of people. However, engaging people in somebody else's problem through the internet is a challenge [1] and research has shown that software design and usability can be an important reason for users to join and engage in a project or a community [2,3]. Likewise, the experience of users is important to the success of mobile learning software, and as a result, some evaluation frameworks have already been developed (e.g. [4,5]). The focus of the present work is to offer some guidelines around the use of these mobile applications for learning, based on our experience from a sensor-based citizen inquiry project.

The Sense-it mobile app, which is fully described in Sharples et al. [6], is used in combination with the nQuire-it platform (www.nquire-it.org) to engage people of all ages in crowdsourcing inquiry activities that allow them to initiate, share, join and contribute to scientific investigations. Sense-it, which activates the existing sensors of Android smartphones and tablets, has been employed in Weather-it, a study that explored the formation, engagement and learning of a citizen inquiry community around weather [7]. Two investigations using Sense-it were created in the context of Weather-it: (a) 'Record the sunlight': people measured and shared the sunlight intensity in different parts of Europe at midday, using the light sensor; and (b) 'Air

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pressure and rainfall': people used the barometric pressure sensor to measure air pressure, while recording whether or not it was raining. Studying the learning gains from participating in these investigations indicated some evidence of conceptual change and learning from unexpected [6].

An important aspect of the Weather-it study was to facilitate ongoing software development. To this end, some forum threads were created to provide participants a place for their feedback during the study. Moreover, at the end of the project, participants completed a survey question that urged them to leave their comments and feedback on the software. The following guidelines are based on the feedback that focus on the Sense-it app, statistical analysis of the sensor measurements, existing literature, and the researchers' notes and reflection. The names members used were changed to names inspired by clouds and winds.

2. GUIDELINES

Maximise the distribution

Several comparative analyses of iOS Apple and Google Play stores have been published by technology experts (e.g. [8]) and academics (e.g. [9]), as mobile app developers are often concerned about which major mobile platform they should submit their apps to. Either option means that the number of potential participants in their research is automatically reduced. For instance, since Sense-it was only available for Android mobile devices, Apple device owners in Weather-it received a negative response on whether they could access the application – and therefore the data collection phase of Sense-it investigations. If maximising the distribution of the app and the participation in the project is essential, then it is necessary to plan for the development costs and specific design guidelines for each platform, while maintaining free access, or take into account the percentage share of smartphone sales for the target group (country, age). In this way, you may prevent or shrink lack of participation due to unavailability of tools.

Allow social login, but provide a wide range of options

Allowing participants to connect with existing credentials simplifies the complicated sign-up process. The use of social login is more familiar to the participants and makes it more convenient for them to join, as they only need to remember and manage one user id and password [10]. However, providing a traditional way of registering with the application will prevent issues such as (a) participants worrying about losing their privacy, and (b) driving away potential participants who have no access to the enlisted social network services. For example, Sense-it allowed only Google account holders to login and as a result, participants were requesting the *"addition of Facebook login"* too. Another important design aspect is whether the mobile app is connected to a web-based platform. In that case, consider providing a way for the participants to merge their accounts. Connecting to the platform via a social network service that is not provided on the mobile app will cause the presence of participants having multiple profiles, as noted by one of our early participants:

"It would be nice if one can login sense-it app with an account different to @gmail… otherwise ppl have to use two accounts in order to participate if they have not registered here with gmail…" (Leste)

The issue was resolved by adding a feature that allows the user to merge the different accounts they may be registered with.

Be wary of the usability, compatibility and limitations of the app

Researchers should be careful not to be overly ambitious about what participants can accomplish without any guidance. On TEL projects or projects recruiting people that are geographically distributed, offering a face-to-face tutorial on how to use and understand the various features of the mobile application is impossible. Therefore, when designing the app, it is important to understand that participants have different levels of (a) digital literacy and (b) learning content understanding:

"I tried to download it but my phone is a couple of years old a Samsung Galaxy and although it runs Android it would not work." (Brisa)

"I wanted to use some of the phone sensors but it was hard to work out what lots of them did/do." (Williwaw)

"Another reason might be that although I discovered thanks to sense-it that my phone has many sensors I could use for the missions, I wasn't quite sure how and what exactly do some of the sensors measure and how could this be used in relation to detecting weather changes etc." (Bora)

A solution provided in our project was to introduce some on-screen help information about each sensor. Furthermore, the continuous feedback on the app facilitated fixing bugs rapidly, such as the ones mentioned in the following text, and maintaining the ongoing development:

"The 'About Sense-it' option doesn't do anything." (Ostria)

"I tried to upload yesterday's light record and when I pushed on the app the cloud icon, it directed me to a link on chrome and it stuck...when I refreshed the page, the data was neither visible here on the platform nor "upload-able" on the app itself. Any suggestions?" (Levanto)

Understand the capabilities of various mobile devices

Mobile devices have a set of capabilities, services and applications to offer to their users. For instance, Sense-it unlocks sensors that mobile devices already have, and thus (a) the sensor measurement methods between mobile devices may differ and (b) the number of sensors participants could use depends on their device rather than the application. One of our participants posted on the 'record the sunlight' forum topic explaining why her phone was not suitable for this experiment:

"I can see a potential problem with this experiment - not with the method but with the equipment used to take the recordings. For example, my phone (HTC One) only measures the incident light in 6 discrete levels, and unless I'm actually blocking out the light with my hand only 10cm above the sensor, it shows the maximum reading. Today it's somewhat cloudy outside and just trying to rain, but the recording I made still stood at maximum for all the data points. (Although the scale on the axis gives me no idea what units it might be using!). Sadly, I suspect my phone is not optimised for this experiment!" (Ostria)

On the other hand, some mobile devices do not support specific sensors at all. Because of that, there were cases where participants (a) started a mission asking from other members whether they could contribute and (b) requested a feature for importing raw data:

"Measure the pressure and add in the title how rainy it is (e.g. drizzling, raining, hailing, etc.) My mobile device doesn't have a pressure sensor, so I need your help!" (Shamal)

"Is it possible to allow for raw data to be sent for a mission? For example, I have a thermometer at my house and I'd like to create a mission to measure temperature and keep history. My cheap Android phone doesn't have a temperature sensor... It would be really useful if I could send the data to the mission through the app!" (Zephyros).

It is essential that researchers do some investigation around the features and the software availability of main mobile device brands, before they decide to engage participants in activities that they may not be able to join.

Be aware of calibration and data reliability issues

As mentioned in previous work [6], calibration is an important issue that needs further investigation, as lack of it may affect the reliability of sensor measurements and furthermore, the quality of results and conclusions. Understanding the software differences between mobile devices can help calibrating the sensors either by using a software setting scale or with statistics, if the participants are geographically distributed.

In order to evaluate how accurate the mobile devices and how reliable the data that participants collected were, we analysed sensor measurements in one of the Sense-it investigations (record the sunlight). The analysis involved four comparative cases (17 pairs of sunlight measurements in the same area and date/time), with mobile devices of same and different brands. The high and inconsistent percentage differences between the pairs in all four cases do not help in scaling the sensors' recording, and moreover, indicate that the project data may not be reliable, raising concerns about the validity of these Sense-it investigations. Practitioners who aim to use collected data to answer scientific questions should consider calibrating the recording instrument and evaluate the measurements.

3. CONCLUSIONS

This paper proposes five guidelines for using mobile apps in TEL research: to maximise the distribution of the mobile app by surveying the numbers and needs of the major mobile platforms in the market; to allow multiple types of logins for making registration more convenient; to allow ongoing feedback and be wary of the mobile app limitations; to understand the capabilities of mobile devices that participants will potentially use for the app; and to be aware of calibration and data reliability issues. This set of guidelines intends to inform the development, adoption and use of mobile applications for TEL by researchers and practitioners, and eventually reduce learner anxiety or disappointment during software use, and enhance the participation and learning outcomes.

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