PocketSchool Interactive Learning Ad-Hoc Network

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Abstract - PSILAN (PocketSchool Interactive Learning Ad-hoc Network) is an interactive mobile learning framework designed for both formal and informal education scenarios with a particular consideration of under-resourced school or village settings. This paper describes how mobile innovation features of PSILAN are designed to help educators rapidly develop and easily deploy multiuser game-based mobile learning solutions and also how such solutions could potentially remain as highly viable and sustainable learning options for learners of all ages and regions. For discussions on implementation and evaluation, this paper presents one of mobile interaction applications developed for PSILAN, insights learned from 5th grade students and teachers in a rural Indian village school, and future development plans.

Index terms - mobile learning, educational game, ad-hoc network, contextualization, sustainability

1. Introduction

Learning is hardly a discrete episode; rather it is an opportunistic experience interwoven in our daily lives made up of numerous tasks and stimulants we encounter [1]. When we are faced with problems in dynamically evolving contexts, we often try to understand and respond with cognitive and physical resources available within and around ourselves at a given moment. Therefore, opportunistic learning moments created with today’s emerging mobile innovations can certainly provide the learner with frequent engagement opportunities. Also, the ubiquity of mobile computing and wireless networking can often enable the learner to chip away large tasks [2] or tackle incidental tasks given the better mood and occasion in snippets of moments in our everyday life. Furthermore, the increasing advantages of mobile learning technology are to become more available for learners of all ages and regions [3]. For example, because of its potential to achieve a large-scale impact due to their portability, low cost, and versatile features, mobile technology offers promising opportunities to combat the deep-seated chasm of inequality entrenched many places on earth [4] and also reach even the most isolated audiences [5]; [6].

In terms of research, numerous studies in the field of educational media and technology have tended to focus on the intersection of technology and learning. Frequently appearing themes in the field are how to use innovative technology to improve instructional designs or how to devise technology-integrated pedagogies to promote higher learning objectives [7]; [8]. Nonetheless, there is very little attention on issues related to contextualizing learning technology or sustaining educational innovations for less resourced schools or underserved regions. For that reason, we are concerned about mobile innovation for education in general, but particularly interested in technology designs for contextualization and sustainment. For this regard, we present PocketSchool Interactive Learning Ad-hoc Network (PSILAN), a decentralized social interaction framework that maximizes mobile learning opportunities in both formal and informal settings while promoting collaborative or competitive team-learning environments in under-networked or no-network regions. We describe how the mobile innovation features of PSILAN are designed to help educators rapidly develop and easily deploy multiuser game-based mobile learning and assessment scenarios that could potentially remain as highly viable and sustainable learning options for learners of all ages and regions.

1.1. Mobile technology in education

Many researchers have pointed out the distinct benefits that mobile devices offer as educational
Tools ([9]; [10]; [11]; [12]; [13]; [14]; [15]; [16]; [17]; [18]; [19]; [20]). Today’s mobile devices can store and deliver a vast amount of information, including a wide variety of curriculum materials targeted to appropriate ages. The rapid advances in information and communication technology (ICT), (i.e., increases in processing power, memory, and connectivity) have made mobile devices more interactive and media-rich than ever before [21], offering a fun and engaging context in which to promote higher learning opportunities. Moreover, unlike desktop computers, mobile devices require substantially less infrastructure and electricity, which gives them many advantages over traditional computers. Most importantly, mobile devices are capable of reaching even the most marginalized communities ([22]; [6]), and research has shown that mobile learning devices have the potential to widen access and supplement education in remote and underserved areas of the world [23]. Also, many have noted that this makes them more apt tools for large-scale impact [1].

Therefore, mobile learning technology of today can certainly play a significant role in addressing the learning needs in underserved schools or regions. At the same time, we acknowledge the multidimensional complexity surrounding issues of learning and believe that mobile learning technology is uniquely positioned to overcome many of them.

Overall, to date, mobile learning technology has emerged at the forefront of discussions in the context of well-developed support infrastructure and technology enriched learning environments. Its prospective role in reducing inequalities is less discussed and hardly considered for billions of underserved learners. Therefore, it is necessary to not only consider mobile technology solutions to mitigate obvious inequalities, but also investigate potential methods and designs of mobile learning models and infrastructure that can ensure sustainable and contextualized (i.e., context and situation aware) mobile learning options for all.

1.2. Games in education

Games are now being recognized as an effective tool to teach or further solidify concepts by many researchers [24]. With the steep increase in popularity of computer games, use of mobile games has also become increasingly common: in industrialized countries such as United Kingdom, 68 percent of children played games on their mobile phones every week in the last decade [25]. Such increasingly prevalent game-related activities along with the high engagement that they often offer make games appear attractive learning tools for educators. Obviously, researchers have recognized the educational benefits of playing games such as relating learnt material into context, acquisition of knowledge and cognitive skills, and accomplishment of attitudinal change ([26]; [27]; [28]; [29]; [30]; [31]; [32]; [33]; [34]).

Among many ways to categorize different approaches to game-based learning, there are two broad categories by the style of content incorporation [35]: Intrinsic and Extrinsic games as coined by Malone [36]. In intrinsic games, content is an integral part of the game structure as in many simulation-type games [35]. Highly engaging games that are based on experiential and/or situated learning would be located near this end. On the other spectrum lies the extrinsic game which incorporates the content less tightly to the game structure. Traditional entertainment software packages that use direct instruction, giving instruction on new concepts and following up with tasks or questions to test the new concept, would fall into this category. Examples would be quiz-show type of games such as Jeopardy! or trivia games, in which the contents can be about any subject and participants can solve challenging quizzes in a collaborative or competitive manner. In the right context, the quiz-type games can serve as strategic formative and summative assessment tools or excellent ways of enabling self-learning reflections or peer evaluations. In short, the key in educational game-based learning design seems to be in creating and maintaining the optimal integration of intrinsic and extrinsic game characteristics, ultimately leading to maximizing motivation and learning. In this regard, Prensky [35] points out that designing solid learning games is a challenging task since it requires a sweet balance among fun, user-engagement, interactive contents, and educational effectiveness. Accordingly, Moreno-Ger et al. [37] points at the high development costs associated with these projects as a major challenge block.

Therefore, it is the intent of the researchers to design and offer a highly engaging, relatively affordable, and easily deployable open source mobile learning interaction framework; help game developers to take advantage of the framework to create multiuser interactive games; help educators contextualize mobile technology to meet local needs of schools; and help accommodate various learning objectives and enhance both formal and informal learning scenarios. We believe such mobile education game network can help create joyful and sustainable educational environments. Especially with the rapid growth of mobile users around the world and the increasing affordability of highly versatile mobile
devices in even remote rural villages, it seems quite worthwhile to explore ways to leverage mobile innovations in education [38].

2. PocketSchool Interactive Learning Ad-hoc Network (PSILAN)

PSILAN is a decentralized real-time interaction ad-hoc learning network framework specifically for pocket-sized mobile devices. First of all, the term, PocketSchool was originated from a series of Stanford University School of Education action research projects focused on mobile education innovations designed to increase basic educational access for children in extremely underserved communities where there is little or no presence of formal schooling facility or literate adults ([1]; [6]). PocketSchool initiative employs a variety of pocket-sized mobile learning devices in its effort to distribute open source education programs to marginalized regions of the world. As shown in Figure 1, rural village children who live and study in one-room mixed-age & grade school without any other resources such as library or even electricity are playing numerous educational mobile games such as storyteller, critical thinking math, farming simulation games, etc.

Secondly, PSILAN is an extension of the PocketSchool project to add interactive mobile game characteristics to traditional education materials and activities (e.g., didactic, unidirectional, teacher-centric, etc.) by adopting a decentralized real-time interaction network architecture from a research project named MobiSocial Junction [39] from Stanford University School of Engineering.

Unlike an application service provider (ASP) model where one big service provider controls an interaction network and grows services with centralized main servers synced with replication servers in multiple locations, PSILAN architecture can be highly decentralized to work with available local network services (e.g., GSM, Wi-Fi, Wi-Max, etc.) and grow to address local needs at various levels (e.g., femtocell, picocell, community, or village network, etc.). For example, if a village has no network of any kind, a simple Wi-fi access point or picocell access point could be turned on to serve as a micro backbone for a small learning network. With a simple access point with default network settings, one can instantly start servicing PSILAN and learners in the coverage area can join PSILAN with available mobile devices that can support the given network. Since the core component of the PSILAN application that needs to be installed on mobile devices consists of less than 1500 lines of code, the mobile application installs quickly over the network and consumes minimal resources of the mobile devices. Because of the simplicity of PSILAN, it could be deployed within hours and easily taken to rural villages or hard-to-reach regions. It is designed so that non-technical people can easily author contents. Therefore, the potential use of PSILAN in under-developed region is quite noteworthy. With or without cellular network coupling (i.e., in order to link with mobile Internet service provided by a cellular network carrier), PSILAN could instantly enable an ad-hoc interactive learning network (e.g., educational games), village-wide mobile survey network (e.g., public health survey), micro-economy development (e.g., village advertisement or marketing survey), social entrepreneurship support network (e.g., village woman empowerment programs), etc.

2.1. Technical details of PSILAN

PSILAN is a decentralized real-time interaction framework designed with XMPP (Extensible Messaging and Presence Protocol) which is often
used by real-time interaction web applications such as Google Wave [40]. PSILAN adopts its core networking architecture from MobiSocial Junction (hereinafter simply Junction). Junction is a decentralized cross-platform application framework, enabling mobile devices in a small vicinity to carry out all the necessary application logic, relying only on a lightweight universal switchboard for routing message packets. Figure 2 shows the high-level architecture.

2.1.1. End-Point Devices

Junction provides the same “click and run” experience as is with simple web applications. Every participating device, be it a server, a PC, or a mobile phone, runs a piece of software we call the Activity Director, which is analogous to a web browser for web applications. A Junction application, called an activity, is a collection of cross platform programs for various devices. Junction extends the notion of a URI to refer to a specific session, which is a dynamic instance of an activity. A single click of the Junction URI (Uniform Resource Identifier) can automatically download the code for a particular platform and launch the application (with confirmation from the user to install the software). This is made possible by the introduction of an activity script, which provides the master plan pointing to all the codes that make up the activity. It declares the roles in an activity and the location of the codes, possibly supporting multiple platforms for each role. Junction also makes it easy to invite others to join a multi-user interaction activity; in particular, it supports proximity applications by inviting participants.

2.1.2. Switchboard

One common problem that all multi-party applications face is how to connect the end points together. Many mobile phones and PCs in multiuser environments are mostly behind the firewall (e.g., NAT - network address translation for home wireless hub) and, not having public IP addresses, cannot communicate directly with each other. Decentralized multi-party applications like Skype use a built-in rendezvous service that enables PCs behind firewalls to communicate with each other. For Junction in PSILAN, we employ a universal, application independent rendezvous service, called the Switchboard, which supports all the Junction multi-party applications. A Junction application initiating a session can choose any node hosting a Switchboard service, as long as it is addressable by all participants in an activity and can route messages between these parties. This messaging architecture can be scaled by simply adding more Switchboard nodes.

For the sake of ease of deployment and experimentation, we have chosen to have the Switchboard simply provide a subset of the XMPP (Extensible Messaging and Presence Protocol) protocol. Standardizing on a universal rendezvous service abstracts from the application writer the details of how end devices find each other. This separation of concern has three important effects. (1) The mobile application developer does not have to worry about providing a scalable service. (2) Optimizing the Switchboard service benefits all applications relying on it. (3) It supports different deployment models that support different privacy and local conditions. For example, a carrier may provide a generic Switchboard service, and a nearby Switchboard may be chosen near, say, the initiator of the multi-party activity. This design tremendously improves locality, effectively minimizes packet delivery latency, efficiently distributes the network traffic, and scales as the local multiuser network grows. A Switchboard service may be easily deployed and operated by anyone (e.g., rural village teacher with minimal technical knowledge) with one at least simple networkable device with minimal computing power (e.g., mobile device, netbook, or plug computer).

2.1.3. Interaction activity design

In PSILAN, a mobile game developer can simply write out the master plan of the game activity in a declarative manner and supply the code for various roles in an activity. An activity script is structured as a JSON (JavaScript Object Notation) object. An example of a script for a mobile game is shown in Figure 3. The “PS1(PocketSchool version 1)” role is available for a single platform — JAVA, as a runnable JAR file. The “remote” can be run either as a native mobile application or as a web application. An interaction activity session has a cast which binds each participant to one or more roles in an activity script.
Every activity has an activity hub which is the keeper of the activity script and the cast and a facilitator of communication between participants. An activity session is identified by a Junction URI, which is a specification of its hub’s location. It has the form junction://<switchboard>/<sessionID>, where <switchboard> is the name of the hosting hub and <sessionID> is the identifier of the hub. An invitation to a role <r> is simply the Junction URI appended with “?role=<r>”. This URI can be generated by any participant of an interaction activity junction and sent to an interested party. A participant initiates the activity session by creating a hub on a switchboard server of its choice. All participants connect to the hub with an activity under one or more specified roles. A junction, like a spoke of a wagon wheel, ties an actor to the hub of an interaction session. Communication with other participants is performed via primitives provided by the Junction object. Every participant is assigned a unique actorID. A participant can send messages to a session, a role or a specific participant; it can respond to a number of pre-defined events which include the receipt of messages, the creation of a session, and joining a session.

2.1.4. Activity Director

With Junction in PSILAN, every device (e.g., mobile phone, netbook, etc.) wishing to run mobile game applications relies on just having one simple program: the Activity Director. The Activity Director integrates the launch of game activities with the host platform for all multi-user interactions. For example, it can download and launch the core code of a game as a user clicks on an invitation. It also leverages the capability of mobile devices to provide more user-friendly ways to share invitations among participants. The above functionality is made possible by the self-contained design of a Junction invitation. Containing the hub information and the role, an invitation provides all the information necessary to retrieve the activity script, download the code for the role and platform, and join the specific session.

As shown in Figure 4, a Junction Quiz game (Left) pushes invitation to all participants to join and start the game. This is one of initiation methods in Junction named, "Push-based solicitation" which can be highly useful in multi-user mobile interaction environment. Basically, the Activity Director can provide a remote-trigger mode to allow Junction games to trigger presentation of everyone’s achievement scores, next clue or sequenced learning stimuli, or certain shared actions depending on game scripts.
3. Implementation of PSILAN Mobile Learning Games

A series of mobile game application frameworks have been implemented based on the Junction infrastructure. Although there are many choices for mobile platforms, the Android platform was chosen for implementation because of its available open-source library including existing network stacks. For the switchboard, Openfire (See [41], an open-source Java implementation of XMPP supporting BOSH (See [42]) and MUC (See [43]) was adopted with no modification. Because of the integration of standard XMPP in PSILAN, pre-existing, well-maintained supporting libraries were also adopted. In addition, Smack library (See [44]) for client-side XMPP messaging was also adopted.

The PSILAN framework enable people to quickly develop simple games that require multiuser involvement, real-time communications, competition-based scenarios, portable mobile devices for anytime and anywhere participations, and multimedia-rich learning stimuli. Although many game scenarios have been developed and tested, for this paper, we present one of simple multi-user interaction games we believe best describe the dynamic features of PSILAN.

3.1. PSILAN Junction Quiz Game Maker

PSILAN Junction Quiz Game Maker offers an assessment/inquiry maker which allows students to quickly generate own quizzes based on their own learning stimuli. The concept behind this particular game is to encourage students to easily participate in generating various types of educational quizzes while holding instant quiz solving competitions with the minimum intervention or coordination by a facilitator/teacher.

For example, students can freely take a photo (Shown in Figure 5) of a diagram from own textbooks or any phenomena discovered in their school garden or lab and generate a quiz or inquiry. All student-generated multimedia quizzes can be tagged by the generators, but rated by peers to indicate how interesting or useful the quiz is to their own learning. Obviously, teachers or facilitators could decide to review the student-generated quizzes from the pool, weed out the ones that may not be relevant and leave only the ones that are highly useful or ones with highest student ratings (i.e., rules could be made at the local level) to hold a quiz solving contest. Another potential pedagogy is to let the students rate each other’s quizzes and decide what should be tossed out, saved, or used for competition games.

The immediate advantages of the quiz maker are in that it 1) involves the learners themselves in the reflection and generation of own learning stimuli and inquiries; 2) makes it possible for students to have anytime/anywhere quiz game generation possibility (where there is an opportunistic learning moment); 3) empowers the learner to generate and incorporate mobile multimedia objects from own environment; 4) allows the learner to rate peer inquiries based on own assessment of the merit; 5) enables a collective management of the inquiry quality; 6) enables any group or organization to track the academic performance of the learner at a granular (based on learning standards) level; 7) makes it possible to conduct a variety of comparison analyses for benchmarking purposes; 8) creates a competition or collaboration game environment with a leader board and score board on both the number of correctly answered quizzes or the highest quality quizzes generated; and 9) allows within class, interclass, inter school-wide, or world competition game scenarios. Overall, this Quiz Game Maker would be well suited for any learning and training scenarios for any age groups requiring learner’s self-reflection, collective inquiry making, and situated experiential learning (i.e., leveraging authentic context, environment, and local culture).

4. Evaluation

For evaluation, an action research approach was employed to investigate the potential affordances of PSILAN in both formal and informal learning environments. Action research has been reported to be an effective research method for technology implication studies often involving challenging or unknown conditions or underserved regions and populations ([45];[46]; [47]). One of the fundamental beliefs of action research is that technology impact
in complex social systems cannot be easily simplified for meaningful study especially when the technology of interest is unconventional. In reality, factoring of an intricate real-world setting into a number of research variables often does not generate valuable knowledge about the whole system [48]. Therefore, this study chiefly focused on observations and open-inquiries to seek increased understanding of the deployment model, multivariate context and its potential implications for further mobile learning model research and design. Various types of data—including field notes from observations, documents from interviews, student achievement scores (i.e., points achieved by each individual, time stamps, etc.), photos, and inquiry types—were collected through the series of interactions with all constituencies involved in this study.

4.1. Procedure

19 5th-grade Indian students and their teacher in a rural village public school located in Southern India participated in the evaluation. Through a convenient sampling, a partnering NGO in the region helped the researcher plan and execute the evaluation of PSILAN. The village was located about 3-hours away (e.g., driving distance) from a major city. The participants were observed, while they were engaged in the competition game activities, and interviewed. This particular school was recommended by the partnering NGO because the village had sporadic access to electricity while overall school infrastructure was poor (i.e., commonly found in rural village schools in developing regions), yet the school principal is enthusiastic about integrating technology in their school curriculum.

Interestingly, the school emphasized the importance of learning English and there were signs on every corner of the school wall encouraging the students to speak English. However, most of the students were able to engage only in basic conversations and short-sentence writing tasks in English. The official instruction was in Telegu and partially in English. Some of the textbooks were in English.

As the initial step, the students were asked to generate questions on paper to get them familiarized with the quiz making process. According to the principal and teacher, most public schools hardly promote activities encouraging students to generate own quizzes as part of classroom pedagogy. Therefore, a warm-up exercise on quiz making was adopted in this study.

As the second step, students were asked to play with the mobile phone and find out what they may be able to do with the mobile phone. Since most of the students were familiar with camera and video features of mobile phones, the student figured out, with little effort, how to take photos or make videos while browsing various features of the phone. After they had the prerequisite activities (e.g., generating quizzes on papers and using the phone to take photos), they were told to use the Junction mobile application to generate quizzes on their own (See Figure 6).

4.2. Setting

The most crucial and only requirement for PSILAN to operate is obviously electricity for the devices involved. The most distinguishable benefit of using mobile devices (compared to desktop computers) was in that the mobile devices run for hours if not days once they are charged. Electricity was not reliable in the village, but charging the devices was not a tremendous issue because devices still charge even with sporadic electricity.
When PSILAN was deployed, an access point providing a Wi-Fi network coverage and a notebook computer serving the Junction Switchboard were brought to the evaluation site and simply plugged into one of wall outlets in one of classrooms in the school (See Figure 7). The participants were given Android phones running Android OS along with the Junction Activity director. The phones automatically identified and signed on to PSILAN SSID (Service Set ID), making the entire deployment seamless and rapid (i.e., less than 10 minutes to start to play. Unfortunately, the electricity in the classroom was sporadically available (i.e., on and off every 20 minutes or so). This brought the access point on and off as the electricity was on and off. However, they spent the most of their time with the phone and the access point was needed only when they needed to interact with the Junction server (e.g., uploading quizzes, downloading quizzes, checking score board, etc.). The facilitator for the activity had to develop a strategy to direct students when to upload, work on generating questions, check for game score, etc.). The battery provided enough stable electricity to power the access point device (Plug computer combining wireless access point, web server [49]).

Figure 7. A plug computer access point was plugged into the classroom-wall outlet.

4.3. Findings

4.3.1. Student learning and engagement

After all evaluation sessions, when the students were asked, none of the students expressed that the Android devices were novel; all indicated that they had been exposed to various mobile devices prior to the evaluation (i.e., thus no novelty effect was observed). For students, manipulating the device was mostly intuitive and did not require any substantial vertical transfer of knowledge. Their eagerness to play the quiz competition game and active participation seemed to have been mostly caused by the gaming and competition characteristics of PSILAN, but not by the introduction of the mobile technology itself.

Figure 8. Car battery(1) to power the wi-fi access point in a plug computer (2) using a voltage converter (3).

In terms of the level of enjoyment, Figure 9 presents their responses. Most students indicated the high level of enjoyment for the game activity.

Figure 9. Level of enjoyment

The quiz generation activity coupled with mobile photo incorporation, critical thinking in generating questions and distracters (i.e., multiple choice or fill-
in-the-blank questions with distracting choices) seemed to have enabled the students to feel "Sense of ownership," increased learner control" and enjoyment.

Figure 10. Reasons for finding the game activity interesting.

Obviously, not all questions were high quality questions. Occasionally, some questions presented with hilarious choices (i.e., based on local nuances) and some with too obvious answers (e.g., "Who is the President of America? a. Aamir Khan b. Sachin Tendulkar, etc.). Such hilarious quizzes or answers brought ample laughter and smile. As indicated by their reasons for finding the game activity joyful, Figure 10 shows the results. The number one reason was that they were able to generate and exchange quizzes. This is the higher level of learning that involves critical reasoning and problem solving to generate good problems. The number two reason was in the nature of the game in getting the student rethink about the learned concepts and facts. Obviously, passive learning is observed in many classrooms of today, but getting students to take control of reflecting concepts and synthesizing them is a mode of active learning which we would like to see more in future classrooms.

Other reasons for enjoyment were in the incorporation of mobile photos (See Figure 11) in their own questions and the competition mood in the quiz game activity.

Figure 11. Sample questions generated by the students.

All students were able to instantly view who won the ad-hoc competition by answering the most questions correctly and also who came up with the best quality questions. Therefore, such instant competition mood seemed to have helped the students get motivated and engaged in the PSILAN activity with joy.

Figure 12. Things they did not like about the game activity

As shown in Figure 12, there were a few reasons they did not like about the game activity. For example, 4 students complained the quality of the mobile photos they took to use in the quizzes. We believe this is an issue with the photo taking skill. In fact, the built-in camera was a high-end camera and it produced high quality mobile photos. However, some students did not have the adequate distance between the camera and the object or did not wait for the camera to auto-focus. Another reason was with the waiting time. Since the electricity was on and off, the students often had to wait for the access point to come online and it caused them noticeable frustration when they already had the quizzes ready to be uploaded. Once the access point was up and running, the connection was not an issue. The last, yet more important complaint was with solving
poorly generated or incomplete questions. Obviously, generating quality quizzes requires an adequate level of critical thinking and problem solving skill which can improve over time with practices. Not all students had such high-level academic skills nor had they been trained on such skills in their regular school programs. Engaging students in critical reasoning and problem solving through PSILAN seemed to be the utmost important feature (i.e., considering the current level of student engagement and simple didactic pedagogy employed by most public schools today especially in developing regions).

Figure 13. Responses on, "How does this activity compare with other classroom activities?"

In terms of comparisons, the students indicated that PSILAN is distinguishable because it uses multimedia in their learning (See Figure 13). This is no surprising because students seemed to enjoy creating their own photos to generate own questions while reviewing what other peers have generated. The current PSILAN version does not enable students to incorporate videos, but it is certainly in the queue for future implementation. Students also stated that PSILAN makes students participate and that is different from other activities. It is probably due to the fact that the most common pedagogy in public school classrooms of today is mostly a routine of teaching and memorizing facts. One point that was not made by students, yet seemed relevant was the fact that the peer assessment piece in the PSILAN design provides each student a tool to gauge own learning standard and progress in the same cohort (i.e., How is everyone doing? How am I doing?). Such assessment aspect enables students to understand how one is performing overall and also how one should catch up if needed (i.e., by examining the quality of inquiries generated by peers).

Overall, the student survey provides important insights on PSILAN in action. As PSILAN is designed to provide a game-like learning activity that maximizes enjoyment, motivation, learning, and engagement, it seems to meet its intended objectives. However, the initial evaluation involves a very small sample group. Therefore, further analyses with many more classes at different grades will help us generalize our initial findings.

4.3.2. Teacher's feedback

After examining the deployment process and student responses, the participating teacher offered a series of valuable suggestions for further enhancement. First, the teacher indicated positively on the fact that PSILAN: does provide ample learner control and engage students in own reflection and learning; can be used in any subject or class; and does not require a technician to set things up except connecting the access point to a battery if needed. Second, the teacher indicated that the student performance tracking feature of PSILAN (i.e., individual inquiries, achievement scores, and inquiry ratings could be reviewed and analyzed in real-time) was the best feature of all (See Figure 14). Third, the teacher also indicated that PSILAN could be used as an ad-hoc assessment tool for general quiz sessions for any subject in school regardless of the competition game characteristics. Fourth, the teacher indicated that with little preparation time for set up and minimum teacher involvement requirement, technology solutions such as PSILAN would be easily adopted and sustained in public schools. Fifth, the teacher indicated that PSILAN activity could be a great opportunity to encourage students to learn English (e.g., since students were often asking the teacher if they wrote the question correctly or if there were any better word for the answer choices).

Figure 14. Teacher's quiz game management system

Overall, the evaluation has shown that PSILAN could be easily deployed in any formal or informal setting as long as there is access to sustainable electricity (i.e., including car, rickshaw, or motorcycle battery). According to the teacher,
integrating PSILAN into existing curricular and learning activities does not seem challenging. However, further empirical studies are needed to investigate potential challenges in its maintenance and possible effects on academic achievements in longer-terms (e.g., a year or two).

5. Discussions

5.1. Issues in current mobile game designs

Mobile game development for education is still in its early infancy stage and finding the ultimate formula to develop games that are educationally meaningful and intrinsically motivational while highly engaging and entertaining is an insurmountable task. It could easily be fun, yet non-educational or educational, yet boring. More specifically, potential problematic scenarios (i.e., making it less feasible or sustainable) in mobile learning designs to date could possibly be summarized into following:

1. [Mobile learning games] employing high-tech solutions, yet far from addressing any learning standards.

2. strongly anchored on learning theories and innovative activities, yet too complicated to adopt or hard to replicate.

3. designed to work for only well-resourced settings and regions (i.e., require reliable network availability, affordable network service fees), excluding under-resourced settings and regions.

4. incorporating entertaining media effects for a limited learning activity; no room to add or expand new or additional activities by teachers.

5. promoting drill and kill activities with minimum student involvement in generating contents or encouraging problem solving.

6. engaging students in repetitive tasks requiring simple kinesthetic, but minimal cognitive processes.

As pointed out by Prensky [33], overcoming all challenges to develop a well-balanced game (e.g., fun and educational) is one side of the challenge. The other side of the challenge is making mobile learning solutions more relevant to local needs, replicable in all conditions, and sustainable in under-resourced regions.

5.2. Opportunities with PSILAN

To date, there are hardly mobile learning games that empower end users to generate, leverage, and reflect on own learning stimuli or contextualize mobile technology to consider and meet local needs. Furthermore, multiuser interaction games usually require operating with a centralized network system. For these regards, PSILAN may not address many of the identified issues and scenarios, but what it may offer to learners of all ages, regions, and conditions could be noteworthy. As mentioned earlier, the Android open-source platform equipped with a series of open-source real-time interaction protocols make it easier for developers to create mobile interaction game activities. In addition, users with little programming knowledge can enhance Activity Scripts to add more game characteristics of competition or team collaboration activities.

6. Conclusion

To the best of our knowledge, PSILAN is the first service architecture focused on supporting ad hoc, mobile and real-time multi-party learning applications developed with a particular consideration of under-resourced settings and regions. It defines an application independent Switchboard service and provides a complete open source development framework to make it easy for educators to rapidly turn traditional education contents into competition or collaboration game-based learning activities and users with minimum technical knowledge to quickly develop scalable decentralized interactive mobile learning applications for various scenarios and settings (e.g., including places with unreliable electricity). Some of the noteworthy merits of PSILAN for educators are in its simplicity in deployment and flexibility in its architecture for activity development (i.e., targeting numerous scenarios and school subjects).

The school which participated in the evaluation had one computer lab with two old desktop computers waiting to be patched up or replaced. Considering the hassle of moving students between the lab and classrooms and advance scheduling requirement, rapidly proliferating smartphones and comparably affordable small-form factor multipurpose computing devices of today seem quite promising to introduce more engaging and motivating learning activities for the learners of the 21st century.

With the introduction of PSILAN, it is the hope of the authors that more exciting and educationally meaningful mobile learning activities in more sustainable models could be developed and proliferated for learners of all ages and regions.
7. References


