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An Implementation of Smartphone-enabled Seamless Learning: a Snapshot Perspective

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Abstract: In the "WE Learn Project" at Nan Chiau Primary School, a smartphone-enabled seamless learning curriculum was employed to support the Ministry of Education's Masterplan 3 goals in primary schools. Using a snapshot perspective, this paper presents analyses and findings from the first trial curriculum unit in Primary 3 English. Briefly, the functional snapshot shows that the smartphone-enabled curriculum enhanced the academic achievement of students compared to the traditional worksheet based curriculum.

Keywords: mobile, seamless learning, primary school, English language, smartphones

1. Introduction

Smartphones are being adopted en-masse throughout the world (IDC, 2012). In a similar parallel, more and more smartphones are being harnessed for education (Norris, Hossain, & Soloway, 2011). Past lessons on ICT adoptions in education have taught us that learning and teaching with the tool is more important than the tool itself. Seamless learning has been conceived as an influential pedagogical framework in smartphone-enabled learning (Chan et al., 2006; Looi et al., 2010; Wong & Looi, 2011). In Singapore, the Ministry of Education (MOE) has developed strategic masterplans by which ICT can be harnessed to enrich the learning landscape (MOE, 2008). One of the key goals in the latest masterplan, the Third Masterplan for ICT in Education (mp3), is to encourage the development of self-directed learners. Self-directed learning is an important skill for the students of today in order for them to gain ownership of learning, monitor their learning and manage new situations they encounter (Tan, Divaharan, Tan, & Cheah, 2011). Some research has reported that self-directed learning also leads to higher academic achievement (Zimmerman, 1989).

Aligned with the goal of implementing seamless learning and cultivating self-directed learners, smartphones were adopted in a trial design and implementation of the Primary 3 English language curriculum at Nan Chiau Primary School. This "WE Learn Project" is a scaling up of the seamless learning initiative in Primary 3 Science (Looi et al., 2011; Zhang et al., 2010). By transforming the classroom from the traditional teacher-centered model to a learner-centered one, the project hopes to enhance the learning outcomes of students. The project is still in-progress and this paper reports on the pioneer smartphone-enabled unit in the English curriculum.

Being a preliminary analysis of the ongoing project, this paper examines student academic achievement during the trial implementation. The research question is "how has the smartphone-enabled implementation affected students' academic achievement?" The snapshot perspective is the lens utilized to analyze the implementation. The snapshot perspective is based on snapshot theory (Murray, 2006) which denotes that there are particular junctures in a project implementation whereby the entities are conceptually whole, providing for discourse and discussion.

The paper starts with a brief literature review of smartphone characteristics, seamless learning, and the theoretical lens, the snapshot perspective. Next, the research design is described. This is followed by the analysis of the smartphone-enabled implementation in the school. The paper will end with further discussion, limitations of the study and the conclusion.

2. Literature Review

2.1 Smartphone characteristics

Smartphones have several characteristics. Cochrane and Bateman (2010) identify 16 types of affordances of the smartphone which they capture in a rubric. They include: image capture, video capture, mobile web experience, text entry, GPS, touch screen, application availability, 3G, WiFi, cost, availability in the country, screen size, and portability. These affordances differ among different smartphone devices. The rubric serves to identify which device is more beneficial for adoption in the classroom. Similarly, Looi et al. (2010) identify 12 affordances for smartphone use in school. They are: platform, form factor, mobility, connectivity, applications, voice, battery, durability, cost, support, features (such as camera, pen-based input, ease of use on the interface, voice or audio), and memory storage. These affordances affect the type of learning activities that can be carried out.

Rather than looking at specific features of the phone, other researchers have examined broader characteristics of the smartphone. Patten et al. (2006) develop a functionality framework based on pedagogy and educational applications for handheld devices. They identify 7 categories which are progressive in nature; that is, each latter category consists of earlier functionality. Moreover, the first few categories contain features that are available in laptops or desktop computers, while the latter ones are unique to handheld devices. The categories are: administration (e.g. calendars, grading), referential (e.g. dictionary, e-books), interactive (e.g. drill and test, graphing), microworld (e.g. models of real world domains), data collection (e.g., note taking, sensor readings), location aware (e.g. museum guide, augmented environments), and collaborative (e.g. co-present games, collaborative environments). In summary, there are many characteristics of the smartphone. These can all be harnessed for various pedagogical designs.

2.2 Seamless Learning

Seamless learning has been conceptualized in the mobile learning context (Chan, et al., 2006; Looi, et al., 2011) and is a broad pedagogy that interacts with technology, teaching and learning (Wong & Looi, 2011). Its chief tenant is that learning is a continuous process across formal and informal learning environments (Looi, et al., 2010). Wong and Looi (2011, p. 2367) further unpack 10 dimensions of mobile seamless learning as follows:

1) Encompassing formal and informal learning
2) Encompassing personalized and social learning
3) Across time
4) Across locations
5) Ubiquitous knowledge access
6) Encompassing physical and digital worlds
7) Combined use of multiple device types
8) Seamless switching between multiple learning tasks
9) Knowledge synthesis
10) Encompassing multiple pedagogical or learning activity models.

A key backdrop of seamless learning is the changing of existing instructional designs for improved, innovative learning. To enhance pedagogical models and teaching practices, seamless learning invites participants to remove constraining seams (e.g. conceptual, cultural, and physical) for continuous and sustained learning.

The tenets of seamless learning have been examined in several studies. Sandberg et al. (2011) examined English learning as a second language for 5th grade Dutch students across

three conditions: lessons in class, lessons in the zoo with a mobile device, and lessons in the zoo with students allowed to take the device home for a fortnight. The group which took the mobile device home had the highest results. When time was controlled for, there were no differences among the groups. It seems that mobile devices help to motivate students to use their out of class time to learn. Besides motivating students, artifacts created by students in seamless learning environments are also important (Wong, Chen, & Jan, 2011). Lin and Hsiao (2011) examine how visual aids (still images and dynamic animation) on the mobile device affect the learning of English vocabulary. They found that animations helped high school students learn English verbs better. It suggests that seams from older pedagogical models can be removed to enhance learning.

2.3 Snapshot Approach

The theoretical lens adopted in this paper is based on snapshot theory (Murray, 2006). The snapshot theory is derived from the Computer Science discipline whereby software programmers use snapshots at critical junctions to generate discourse in a software development. Entities in a snapshot must be conceptually whole in order to provide a frame for discussion. This research adapts key concepts in snapshot theory and utilizes it as a framework for analysis. Snapshot theory proposes that explaining a phenomenon requires a series of snapshots that have particular characteristics and relationships. These snapshots typically start with an *infrastructure* snapshot (main features of the tool), followed by an *advanced infrastructure* snapshot (further knowledge of the infrastructure composition, enriching the older snapshot), a *functional* snapshot (how the tool functions with the features of the tool), and an *example* snapshot (how the tool works). Snapshots can be weak or complete. A weak snapshot denotes incomplete insight while a complete snapshot encompasses all details to explain the phenomenon.

3. Activity Implementation and Research Design

The project implementation team involves a project manager, two English teachers, the English subject head, a curriculum designer and two allied educators. The team decided to start with the mobilization of a unit in the Primary 3 English curriculum, which had the theme of “mystery”. The smartphone-enabled curriculum was rolled out to three classes in late March 2012 by two teachers. The entire smartphone-enabled curriculum was taught in 12 periods (6 hours) over 2 weeks to the classes. These three classes will be hereby known as red, blue and green. One teacher taught two of the classes (class Red and Blue) while the other taught the class Green. As this was the pioneer activity, an allied educator and the curriculum designer were present during the lessons to support the teachers.

A mixed methods study was designed involving qualitative and quantitative data. Academic achievement is measured in terms of students’ grades. For quantitative data, the implementation team designed an assessment to measure students’ English academic learning. The test had 5 sections covering the following: Vocabulary, Identification of noun and verb, Tenses, Metaphors, and Antonyms. The total score was 30.

A pretest-posttest design was conducted for the smartphone-enabled classes. Two other non-smartphone-enabled Primary 3 classes were chosen as control. These classes used the traditional curriculum which was worksheet-based. For the control classes, only a post-test was administered. The pre-test was administered before the smartphones were used for any learning activity. The post-test was administered after the unit was taught, two weeks later. The questions in the pre-test and post-test were identical. Students took about 30 minutes to complete the test.

For the qualitative data, during this first stage of the project, the researcher took the stance of an observer as participant (Gold, 1985; Kawulich, 2005). Basically this variant of the participant observer methodology allows the researcher to be made known to the members of the implementation team. The researcher's main role is to collect data and the researcher is not considered as a member of the team. The team controls the level and amount of information given to the researcher. It is membership at the periphery. Data was collected from official team meetings, teacher reflections and several lesson observations that the researcher was allowed to observe. The researcher also had informal conversations with members of the team. Field notes were written and data was triangulated.

4. Analysis of Smartphone-enabled English Seamless Learning

4.1 Infrastructure snapshot

This pertains to the tool, the smartphone employed in the project. Here is a list of the main affordances of the smartphone:

- Platform: Windows Phone 7.5
- Form factor: lightweight
- Image capture: back-facing camera
- Internet connectivity: via 3G and WiFi
- Touch screen
- Voice: recorder
- Video: recording and streaming
- Applications: Among other applications available in the Windows marketplace, the project had a specially designed suite of software termed myDesk with three main applications
    - Map-It: mind-mapping application
    - Sketchbook: a drawing tool
    - Blurb: structured note-writer
    - These suite of software was supported by a myDesk learning management system for teachers to view, manage and grade students work

4.2 Advanced Infrastructure snapshot

This pertains to how the features of the smartphone can be harnessed for English language learning. In this study, each student had a smartphone, and the device was with them 24 x 7. This pedagogical choice, the dimension of across time in seamless learning, encouraged students to use the smartphones for learning in class and out of class.

Vocabulary: The unit started with the teacher reading a story which had a mystery theme. Students mapped the story using the smartphone application "Map-It". This encouraged them to remember the new vocabulary. In addition, students used the dictionary application to search for the meaning of new words. Students seamlessly switched between the learning tasks, from the storytelling activity, to dictionary search due to the availability of the smartphone and its applications. Teachers also encouraged students to audio record themselves reading a passage using the audio recorder and to search for the word meanings at home, encouraging self-directed learning and informal learning.

Identification of noun and verb: Using the application Blurb, students were given words such as "spy" and tasked to write sentences using the word as a noun and as a verb. Students were tasked to write a few sentences in class and to write a few more sentences after the class, at their own time. Students were also challenged to come out with these kinds of words, and write a sentence. This learning activity emphasizes seamless learning encompassing formal and informal environments.

Tenses: Students helped each other to take a photo of each other using the camera function and then used Sketchbook to create a disguise. Students learnt about tenses as they annotated what they did in Sketchbook. For instance, after drawing curly blue hair on herself, the student wrote, "I drew a wig on my hair". While this activity was dominantly about personalized learning, to a certain extent it had an element of social learning as students had to cooperate in taking the picture.

Metaphors: For the activity on similes, students either took a picture or drew an image of the simile and annotated it e.g. as busy as a bee. Once again, teachers encouraged students to do this activity out of class. Several students took pictures of ants and flowers from the school garden or at home. Others took pictures of animals like pigs or bees from objects at home. This activity encouraged seamless learning in formal and informal contexts.

Antonyms: Using Map-It, students identified and classified positive and negative antonyms. Students started the activity in class and were encouraged to continue it after school hours, allowing formal and informal learning.

4.3 Functional snapshot

How did the smartphone function to help in student's academic achievement? The paper provides a functional snapshot through examining the quantitative results.

4.3.1 Pretest and Posttest results of smartphone-enabled classes

There were a total of 114 students in the 3 smartphone-enabled classes. Students on average scored 22.69 for the pre-test and 25.88 for the post-test, a difference of 3.18 between the two tests. A paired samples t-test showed a significant difference of $p<.001$ between the two tests. This indicates that the smartphone-enabled curriculum improves the English content knowledge of students.

A sectional analysis was performed and there were significantly higher scores for section 1, 3, and 5(vocabulary, tenses, and antonyms), with most improvements in section 3 and 5. However, there was no significant improvement in sections 2 and 4 (identification of noun and verb, and metaphors). A possible implication derived from the results is that these aspects are difficult for Primary 3 students to grasp. The intervention seems to help students gain more vocabulary but they may not know how to use these words correctly.

The data was compared across the three classes and slight differences were found. For class Red, there was a significant improvement for vocabulary and tenses but little improvement for identifying noun and verbs, metaphors and antonyms. Class Blue had the most improvement, demonstrating significant increases for sections 1, 3, and 5. Class Green showed significant improvement for the understanding of tenses and antonyms but no significant increase for vocabulary. There was also a decline in scores for sections 2 and 4.

As the school practices ability-grouping, class Red was regarded as high ability, class Blue as mixed ability, and class Green as lower ability. These differences in results across classes could be due to the student ability levels and their prior knowledge. For instance, high ability students already have a good grasp of English content and so did not learn much more for antonyms during the lessons. Mixed ability students who may not have much prior knowledge were able to gain the most from the smartphone-enabled curriculum as seen by the higher number of sections that improvement was shown. For class Green, the lack of prior knowledge could have affected their results.

Another possible reason could be how the teachers taught the unit. Teachers gave different amount of challenges and tasks to students. For instance, Class Red was given 5 words to write sentences in nouns and verbs. For Class Blue and Green, students chose one word only. Given a similar amount of time, teachers did not enact the smartphone-enabled curriculum in the same pace, catering to the learning abilities of the students in the class. It could be that given more time and tasks, class Green could have had similar results as the other classes. Nevertheless, the mixed results for class Green suggests that revised strategies in helping lower ability students are needed, especially for students to grasp difficult concepts such as metaphors.

4.3.2 Posttest results of Smartphone-enabled and Non-smartphone-enabled classes

Two other classes acted as control classes (68 students). In the control classes, students were taught the same content using the traditional teaching method which is dominated by worksheets. The mean score for the post-test for the smartphone-enabled classes was higher at 25.88 compared to the mean score of the control classes, 21.25. Welch's t-test was performed between the experimental classes and the control classes. The test showed that the mean scores were significantly different at $p<.001$. This suggests that the smartphone-enabled curriculum intervention helps students gain higher test scores.

Similarly, a sectional analysis was conducted. Students in the experimental classes had higher means for all sections compared to the control. All sections were significantly different except for section 4. This suggests once again that metaphors are a challenge for Primary 3 pupils to understand. Indeed, upon hearing this, the teachers agreed at once how it was conceptually difficult and explained that this is the first time students were taught this. Nevertheless, the smartphone-enabled curriculum compared to the non-smartphone-enabled curriculum enabled the students to improve on the other aspects.

While these results are positive, they could have been skewed due to one of the control classes being of a much lower ability. A further statistical test was conducted to compare between class Blue and a control class which was regarded as being slightly higher in ability. The total score for class Blue was 25.84 while the control class scored 25.86. There were no significant differences between the total scores of the two classes. However, sectional comparison showed significant differences for vocabulary and antonym learning. The smartphone-enabled class had significantly higher scores in these two areas. On the other hand, the control class had significantly higher scores than the smartphone-enabled class in sections 2 and 3. There was no significant difference for scores in section 4.

Based on these results, the smartphone-enabled curriculum seems to help mixed ability students attain scores on par to their higher ability peers. However, in terms of emphasis, the smartphone-enabled curriculum helps to build content knowledge more than the application of that knowledge. As this is a trial phase, revisions to the smartphone-enabled curriculum are needed to enhance students' application of the content.

5. Further Discussion, Limitations and Conclusion

5.1 Smartphone characteristics

One of the instrumental affordances of the smartphone as described earlier is connectivity. In this implementation, the smartphone was connected to the Internet which allowed students to utilize many online applications. Moreover, the specially designed suite of learning software was web-based and relied on Internet connectivity. This design allowed the teachers to access student submissions easily through a web portal. However, during the trial, the Internet server became unreliable and students could not use the web applications. Over the weeks, these technical issues were gradually resolved via great effort by various members and extended members of the team. Teachers also adapted to the various situations and used the smartphone where possible. This highlights the importance of inter-related technological systems in the infrastructure snapshot.

5.2 Seamless Learning

In this implementation, seamless learning has been enacted in various ways. The smartphone-enabled curriculum appropriated several dimensions of seamless learning as

espoused by Wong and Looi (2011). In particular, the dimension of formal and informal learning bears further discussion. As noted in past literature, there are many definitions of these terms. Some definitions have sharply delimited the boundary as the physical school environment (Spikol & Milrad, 2008), while others focused on learner autonomy (Looi, et al., 2010) or other variations (Chen, Millard, & Wills, 2008). In this study, informal learning was still more teacher-led. While such informal learning is noteworthy, the study could go further to develop and encourage more student-led incidental learning, to bring about deeper seamless learning.

Nevertheless, seamless learning using the smartphones has generated an incidental motivation effect. Teachers noticed an enthusiasm in the students to re-do their assignments. After going through the errors and misconceptions of student's submitted assignments, many students came forward to submit their assignments again. This was relatively easy for students' to do as they could just access the assignment online on their smartphones and click a button to submit. The increased motivation for the learning tasks could be one of the processes that the smartphone-enabled curriculum could have brought about and which led to the positive results for student's English learning.

5.3 Future Directions, Limitations and Conclusion

As the first trial implementation, the results provide support that the smartphone-enabled curriculum can help students to improve their academic English. Specifically, the implementation seemed to be able to help students in building vocabulary and understanding the different types of tenses. However, the results must be interpreted with some caution. There were several limitations in the rigor of the test. Firstly, there was a short duration of 2 weeks between tests and what is reflected in the test may not be internalized by the students. Second, the presence of other helpers during the smartphone-enabled curriculum could have influenced results such as the additional attention paid to the student by the allied educator and curriculum designer. Third, the smartphone-enabled classes took the pre-test before which could have pre-conditioned them for the same post-test.

Going forward, for greater evidence of student's learning, more specific examples of individual students' learning are needed. The snapshot analysis provided did not provide an example snapshot partially due to the lack of access to students at this juncture. The processes between the activity facilitated by the smartphone and how the student learns will be examined in future. In addition, the team intends to routinize instructional activities to help the student focus on learning with the tool. Furthermore, a clearer pedagogical direction is needed to guide the process of learning such that key goals are met.

These results and analysis provide crucial feedback of the progress of the trial implementation of the smartphone-enabled Primary 3 English curriculum. The snapshot perspective, in particular, allows crucial junctures of the implementation to be analyzed for further discourse. In addition, from the results of the survey (the functional snapshot), the team, especially the teachers, were encouraged that what they were doing made an impact in their students' learning. The team is in the process of mobilizing other units for implementation in the classroom. Research is underway analyzing the various ways and levels the smartphone adoption has impacted the school.

John Dewey, an American philosopher and educator once said, "Education is a process of living and not a preparation for future living." As the team revises the curriculum, they are becoming more cognizant of identifying the processes of learning. They are learning new things everyday just as their students are gaining a better understanding and knowledge of the English language. Indeed, this is another fruitful dimension of "WE Learn".

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