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FROM DEVICE CENTRIC TO PEOPLE CENTRIC UBIQUITOUS COMPUTING: PRE-SERVICE TEACHERS USING TECHNOLOGY ACROSS SPACES

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The first part of this study examines the ICT devices that a large group of pre-service teachers (*n=107) owned and used for different purposes. The second part of this study takes a closer look at how three pre-service teachers in Singapore used different computing devices across different spaces. The combination of these two parts provides a snapshot of the teachers' ubiquitous computing experiences and sheds light on how their ICT experiences affected their learning and consequently, their teaching. It is found that in general, pre-service teachers owned more than one mobile device and they chose which device to use according to their needs and situations. They generally also showed high usage rates for ICT applications. The data collected from the three pre-service teachers provides more details. For example, the mobile device most often used for work-related purposes (whether as a student or as a trainee teacher) is the laptop and the usage of the various devices is limited by the ICT infrastructure of different locations. Their perceptions and beliefs of the various devices and their affordances are also reflected in the second part.

Keywords: Ubiquitous computing; ICT environment; digital natives; people-centric; seamless integration.

1. Introduction

Personal computing technologies are increasingly widespread in the lives of students, influencing many aspects of their social and work lives, as well as many of their leisure activities. Ubiquitous computing initiatives are already expanding in educational contexts and the role of ICT for teaching and learning has been widely acknowledged. Since the early 2000, education colleges in the US such as University of South Florida, Pennsylvannia State University and University of Texas at Austin, have implemented laptop initiatives for their trainee teachers and faculty (Barron et al., 2008; Murray & Zembal-Saul, 2008; Resta, Abraham, Gerwels, & Tothero, 2004). Research showed that the use of computers in teacher education programs better prepares future teachers for integrating technology into their own instructional practice (Fullan, 1999). Resta (2002) emphasized that it is essential for future teachers to immerse in technology-rich environments throughout their preparation in order to assure that they are comfortable and competent in integrating new tools into their instruction. Teachers are, after all, the agents of change in their classrooms and they also have a profound influence on students' attitudes toward technology.

Ubiquitous computing initiatives are expanding in education environments and Singapore is no exception. ICT has always played a central role in Singapore's education system in preparing our students for 21st century learning. To date, the Ministry of Education (MOE) has implemented three Masterplans for IT in Education (http://www3.moe.edu.sg/edumall/mp3/mp3.htm.). ICT skills for education have been an integral part of the teacher training program at the National Institute of Education (NIE).

In January 2009, NIE introduced a laptop loan scheme for all new pre-service teachers, also known as a one-to-one laptop initiative. The pre-service teachers were given an option to take a laptop on loan throughout the duration of their course in NIE. These laptops are installed with various educational software (e.g. Hot Potatoes, SoftChalk) to both encourage and facilitate the pre-service teachers' use of the laptop for both teaching and learning. The purpose of this scheme is to "enable the pre-service teachers to immerse themselves in a culture of pervasive and effective IT use early in their teaching career" in the hope that these pre-service teachers would be "able to continue to leverage on IT in their lessons when they are teaching in schools" (http://www.acis.nie.edu.sg/notebook). In other words, MOE was attempting to create a ubiquitous computing environment. A ubiquitous computing environment is one where technology is completely incorporated into our lives (York & Pendharkar, 2004).

However, a one-to-one laptop program alone does not automatically mean that a ubiquitous computing environment is created or achieved. There are also other factors to be considered. NIE is only one part of the pre-service teachers' lives. A truly ubiquitous computing environment looks at how ICT is involved in all parts of their lives. The ICT support infrastructure of schools in which they go to for their practicum is also very important, and so is their personal space – that would generally be their home space, and other areas where their personal activities are conducted. Physical spaces aside, the

mindset of the pre-service teachers toward computing is another major contributing factor. As Bahr, Shaha, Farnsworth, Lewis, and Benson (2004) said,

"Attitude remains the critical factor in feeding the drive towards progress." (p.1)

Very often in reality, ICT is "oversold but underused" in classrooms. In order to ensure that this trend does not continue, it is best to address contributing factors/problems at the pre-service teacher level. It is of little use to only provide the physical infrastructure if the pre-service teachers have no interest in using them. Availability and adoption need to go hand-in-hand, as one without the other would be ineffective.

The use of technology in education is becoming more and more prevalent. Pre-service teachers play very important roles in this environment as education is taken to a new frontier. They are the next generation of teachers. Many of them are young and are considered "digital natives" (Prensky, 2001), people who grew up with technology and are supposedly very comfortable with technology. However, just because they grew up with technology does not necessarily make them "natives". In studies done by Chen, Lim, and Tan (2010), Bennet, Maton and Kervin (2008) and Tezci (2011), it was found that although there were "high levels of ownership … and high levels of some academic and recreational activities, only a minority were engaged in creating their own content and multimedia for the Web." The study also noted that "a significant proportion of students had lower level skills than might be expected of digital natives".

So far, studies done in the area of pre-service teachers' perceptions of laptops seem to be more quantitative (Drazdowski, 2004; Fluck & Dowden, 2011; Prestridge, 2012; Resta, Scott, Bin-Taleb, & Tothero, 2006). These offer only a generic view of their perceptions. There have also been studies about the need for training in education technology for pre-service teachers (Beaudin & Hadden, 2005; Murray & Zembal-Saul, 2008). In 2008, there was also a study done in Singapore, which looked at the general attitudes of pre-service teachers toward computers (Teo, 2008).

This study is unique in that it first gives a generic view of the ICT devices that a group of pre-service teachers (n=107) owned and their levels of adoption of various ICT activities, then zooms in and provides a deeper and more detailed insight on the ICT usage by the three specific pre-service teachers – a proficient user, a moderate user and a basic user. It looks at the main spaces that these three pre-service teachers engaged ICT in, at how well these pre-service teachers have used and integrated the affordances of ICT in these spaces into their lives, and how some of these affordances overflowed across spaces. It is a people-centric study, focusing on the interaction between the pre-service teachers and multiple devices and environments they engaged, and the attitudes of the pre-service teachers toward ICT in these environments. The qualitative aspect of the paper aims to complement the quantitative aspect by enriching the data.

The three spaces that are studied in this qualitative part of this paper are NIE, the pre-service teachers' personal spaces and the schools they (the pre-service teachers) went to for their practicum. These were the primary spaces where the pre-service teachers spent

most of their time. These ICT environments are important because they can play an important part either in assisting the adoption process (of ICT activities) or in impeding the use of ICT activities.

The purpose of this study is to draw a richer, more detailed picture of how pre-service teachers used technology and their experiences with it. This insight could help policy-makers and stakeholders integrate the use of technology appropriately in teacher education. It could form the basis of more effective career screening and aptitude testing. Data collected from the study could also be used to provide valuable feedback for evaluating the one-to-one laptop initiative.

Based on the main objective of examining this new generation of pre-service teachers' technology experiences in a ubiquitous computing environment, this study addresses the following questions:

1) To what extent do pre-service teachers access and use an array of ICT devices and applications for everyday life and for teaching and learning, and how?
2) To what extent do pre-service teachers access and use an array of ICT devices and applications for information consumption and for content creation, and how?
3) What factors account for different levels of usage?

2. Research Design

The methodology used is a mixed methods design. First, the results from the analyses generated from the survey questionnaire are studied. This provides a snapshot of the pre-service teachers' ICT adoption levels. Then three specific case studies are looked at. A case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context using multiple sources of evidence (Yin, 1989). It has been commonly used in different fields in social science and education is of no exception. A case study is a useful method to gain insight and interpretation rather than hypothesis testing (Merriam, 1988). It emphasizes process and meanings and is undertaken to get a closer look at the investigation of a phenomenon to add dimension(s) to what is already known through previous research.

The survey was conducted with pre-service-teachers who were at the end of their training period at NIE. These pre-service teachers had borrowed a laptop from NIE during their period of study under NIE's one-to-one laptop scheme. Most of these pre-service teachers were from the post-graduate diploma in education (PGDE) programme. They were asked to fill in the web survey on the computer systems that were set up in the school library. This was done during the period they were given to return the laptops. The research team also sent out an email with a link to the survey to the students who did not take part when it was conducted in the library. A total of 107 responses were collected.

The data collected for the qualitative analysis (case studies) was from three pre-service teachers (Steve, Kenneth and Nicole), all of whom took up the option of borrowing a laptop for the duration of their studies in NIE. These three pre-service teachers were selected from a group (of pre-service teachers) who responded to a call for volunteers for a year-long study (in the use of ICT). They were selected because of their

different usage levels, evaluated by the administration of a survey. All three of them were pursuing their PGDE then and have since graduated.

3. Context

Pre-service teachers pursuing their PGDE in NIE have to go through a year-long training program. In the course of the training program, they have to undergo a ten-week long practicum (or teaching practice).

4. Data Collection

For the survey, the pre-service teachers were asked questions about the ICT devices they own, their time spent on ICT devices and how much of ICT tools/activities they engaged in, including those they used for teaching and learning. The case studies adopted a "phenomenological inquiry" to "inductively and holistically understand human experience in context-specific settings" (Patton, 1990, p. 37). Areas of inquiry included examining how learners used laptop computers in the ubiquitous computing environment, and how this impacted their learning and teaching. The data collected included: (1) Reflective diary: A diary template was designed by the researchers, consisting of a table whereby the pre-service teachers recorded their technology usage pattern in terms of time and place, devices and applications used, and purpose; and an open response section whereby they reflected on their personal use of technology. (2) Interviews: Periodic interview sessions were held with the focus group. A semi-structured interview was employed at each session, as this offered a more flexible way to approach different participants while still focusing on the same area of data collection. The questions were designed to probe into the pre-service teachers' perceptions, attitudes and use of technology. Each interview was about one hour long, and was recorded and transcribed. The figures in the findings represent the data collected from the survey, and the data from the three pre-service-teachers is presented after that to give a richer picture of how ICT was used by them.

5. Findings

5.1. *Ownership and usage of ICT devices*

As can be seen from Figure 1, most of the pre-service teachers surveyed owned at least one mobile device and the device that everyone had, was the laptop. Most also had a desktop and a Smartphone. Slightly more than half of them owned portable media players (PMPs). Netbooks, game consoles and ultra-mobile personal computers (UMPCs) were less popular with this group of student-teachers.

From the case study group of student-teachers, Steve and Kenneth had their own laptops in addition to the ones on loan by NIE. Nicole had a desktop at home. Only Kenneth carried a Smartphone, although all three of them carried mobile phones.

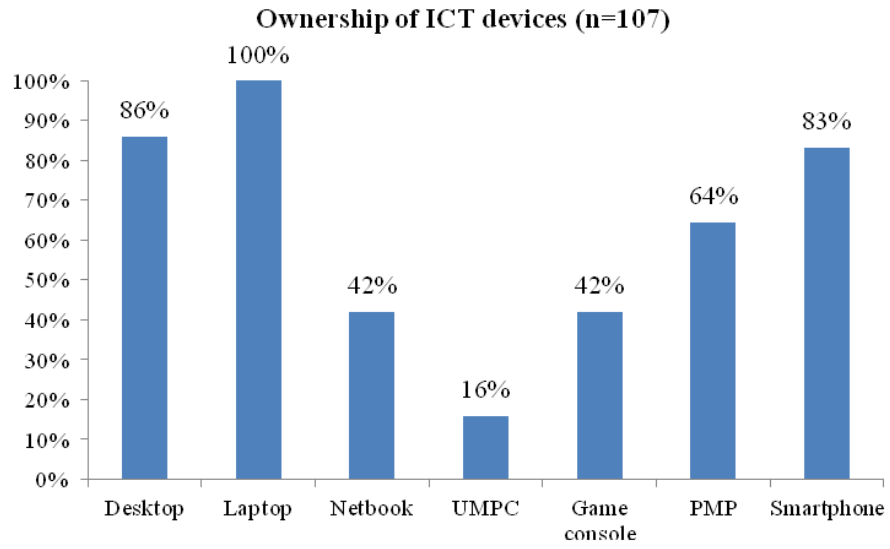


Figure 1. Percentage ownership of ICT devices.

According to the group of student-teachers (Figure 2), most of them spent between 3-7 hours online on a typical day. Very few of them spent either less than 3 hours a day, or more than 7 hours a day on ICT devices. This means that on the average, most of them spent about 35% of their waking hours using ICT devices.

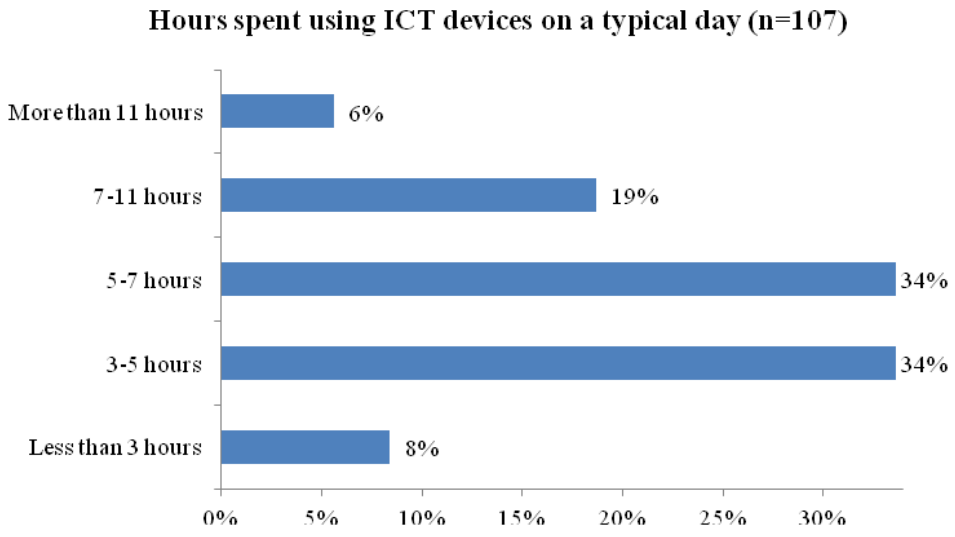
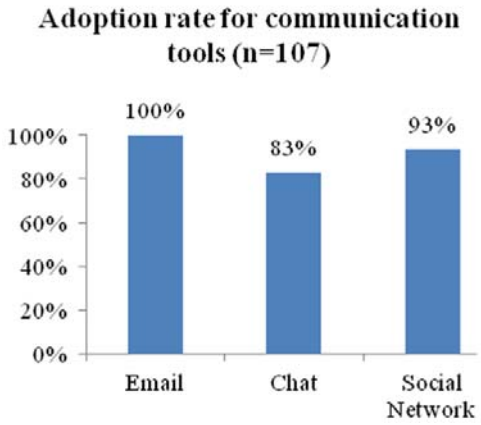


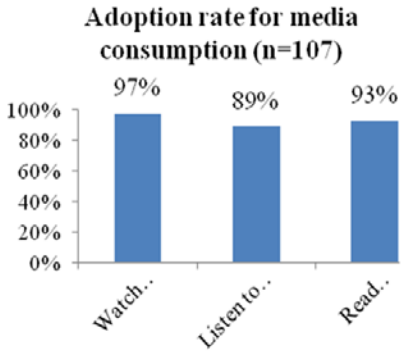
Figure 2. Number of hours spent on ICT devices on a typical day.



Communication tool	Average time spent in a week (hrs)
Email	2.46
Chat	1.43
Social Network	2.93

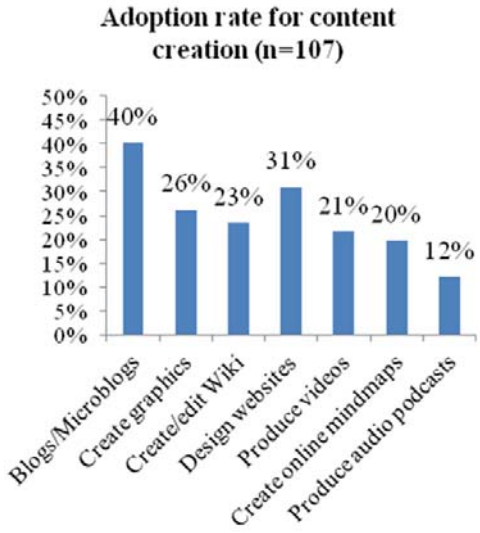
Figure 3. Percentage of those who adopted ICT for communication and the corresponding table showing the average time spent on the respective tools in a week.

Figures 3, 4 and 5 show the respective percentages for the three categories of ICT usage. As can be seen from the graphs in the figures, the levels of adoption of ICT for communication tools and media consumption were generally higher, with a large majority of the student-teachers using ICT to carry out activities like sending emails, chatting, watching videos and such. The average number of hours spent in a week carrying out the respective activities is shown on the table next to the charts for the respective categories. However, the adoption rate for using ICT to create content is significantly lower. The activity with the highest level of adoption for content creation is blogging and only 40% of the students in this group did so. The average amount of time spent on content-creating activities is also much lower than that for communication tools and media consumption.



Media consumption	Average time spent in a week (hrs)
Watch videos/video casts	1.68
Listen to music/audio podcasts	1.56
Read online news	1.82

Figure 4. Percentage of those who adopted ICT for media consumption and the corresponding table showing the average time spent on the consumption in a week.



Content creation	Average time spent in a week (hrs)
Blogs/Microblogs	0.44
Create graphics	0.56
Create/edit Wiki	0.27
Design websites	0.83
Produce videos	0.37
Create online mind maps	0.28
Produce audio podcasts	0.16

Figure 5. Percentage of those who adopted ICT for content creation and the corresponding table showing the average time spent on content creation in a week.

From Figure 6, it can be seen that the most common tools for teaching and learning were using presentation software, creating online assessments, using online resources, using web 2.0 tools and using emails.

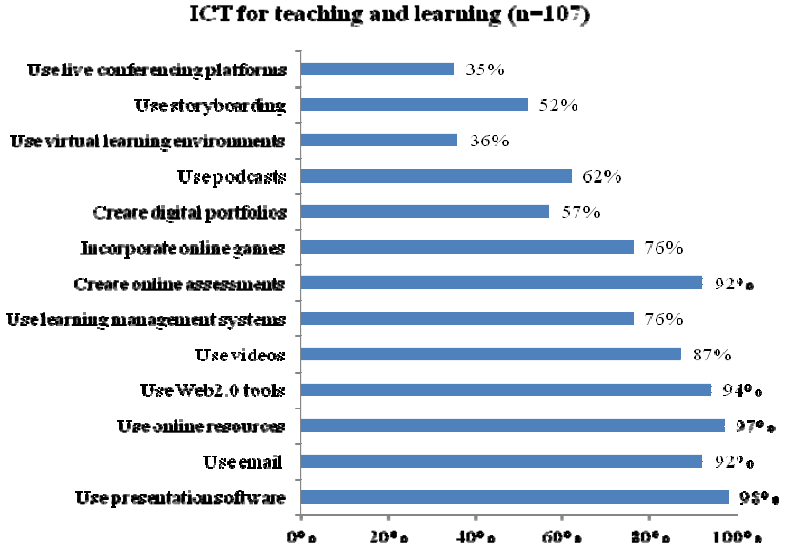


Figure 6. Percentage of those who adopted ICT for teaching and learning.

All the information presented so far show the adoption rates of various ICT activities. The next part of the findings will focus on the adoption of ICT activities in different spaces, and see if the adoption levels and usage of ICT activities remain the same in different places as the student-teachers took on different roles in different spaces. In NIE, they functioned as students; in their personal spaces they functioned according to their needs and preferences; in their practicum schools, they functioned as teachers. Knowing how much of ICT they used shows only one part of the big picture. Understanding the attitudes and beliefs behind their ICT usage will help to see the rest of the picture more clearly.

5.2. *Using technology in different spaces*

5.2.1. *In NIE (as students)*

Steve and Kenneth brought their laptops to NIE almost every day. Nicole would bring her laptop only when she needed to use it for a presentation or when an instructor made it compulsory to have a laptop in class.

Nicole described the laptop as “cumbersome and distracting”. She said she did not use it much in school as her classes were quite closely packed. When she needed a desktop, she would book one to use in the library. She also preferred to use the computer in the library as it is too slow to stream videos so she would focus only on her work. Whenever she used her laptop in school, she had a tendency to get distracted and watched videos and chatted instead of doing what she was supposed to be doing. Describing her laptop as “distracting” hints at some negativity in the way she perceives the laptop.

When in NIE, most of them used their laptops for doing their school assignments like typing out their assignments, preparing lesson plans, preparing PowerPoint slides for presentations and surfing the Internet for resources and information. Steve also used his laptop to take down notes during lectures and tutorials. He felt typing was faster and it was easier to organize information on a computer. In his opinion, the laptop also allowed information to be disseminated easily. Once, he was challenged to make his presentation livelier, so he spent time learning how to use Flash. He described the process as “tiring and time-consuming”, but the end results were “satisfying and fulfilling”.

Nicole preferred to use the pen and paper to take down notes as the laptop took time to start up and switch on. She believed that books were more credible than websites, less stressful on the eyes, easily available, easy to read and flip, and holding a book felt “real”. To her, IT was very “exasperating”, especially when she had to deal with applications for the first time and had little time to explore how it could be used. She found the huge amount of resources available online to be “confusing”.

When her fellow student-teachers simulated classroom lessons using IT, she felt there was generally no clear purpose or objectives for applying IT activities to their teaching. The lessons conducted by them were fun and creative but she felt no learning took place.

However, she liked chatting online for group projects because links could be sent and viewed immediately and a discussion could take place straightaway. She perceived ICT

as something she had to somehow learn as there was a lot of hype surrounding it and more and more schools were using ICT.

Nicole transitioned between traditional methods of communication and technology-enabled methods of communication. She felt a need to embrace these new methods, but at the same time, she thought that the use of ICT took away communication as she knew and was familiar with, and this might have scared her so she tried to hold on to what she was familiar with as much as she could.

While Nicole saw new programs and tools as "exasperating and confusing", Steve embraced them. This marked difference in attitude could be due to the difference in how comfortable they were on the whole using technology.

5.2.2. *In their personal spaces*

In their personal spaces, e.g. home, their activities on their laptops were generally as follows - all of them checked emails, chatted online, played games, logged on to Facebook, watched videos online and movies. Additionally, Steve also edited his photographs and watched online television, Nicole watched Japanese animation and read online comics, and Kenneth did graphic design. Their leisure activities on the laptop were mostly similar.

Steve said he was very comfortable with technology. He usually turned on his laptop the moment he got home. He enjoyed exploring new tools and applications. Kenneth mentioned he liked to multi-task on his laptop. He would search for information or surf the Internet while playing music in the background. He did these while chatting with friends online and at the same time, was also logged on to Facebook. However, he sometimes preferred chatting with his friends face-to-face as he said it felt "more human". Kenneth also used his Smartphone to access the Internet when he did not have his laptop with him, especially when he was on the move.

Although Nicole stored her photographs digitally, she preferred having them printed out so she could "hold and feel" them. She also preferred sending and receiving cards (made of paper, and not e-cards) for the same reason.

Kenneth and Steve brought their laptops with them on their holidays. Kenneth ended up not using his laptop as the first place he went to did not have free Internet access and he said that taking a break from technology, especially the Internet, was very "refreshing", although he felt "lost". The second place he went to had Internet cafes, which he visited. Steve used his laptop as a storing device for his photographs. He would surf the Internet only when there was free Internet access. He also played games on his laptop while overseas. Internet access among some of them seemed to be a preference, but not a strong one, as they would only use it when it was offered for free (when they were overseas).

All of them, except Steve, said that they used their laptops less during the holidays. Only Steve's laptop usage did not drop during the holidays. Their laptop usage was inconsistent during the school term and when they were on holiday, indicating that the laptop was more often used for work and it may not be well integrated in their personal lives.

5.2.3. *In their practicum schools (as trainee teachers)*

When they went to the respective schools they were posted to for their practicum, the computing environment changed. Some of these pre-service teachers faced more drastic changes than others as the ICT standards across schools could be very different.

All the schools did not provide the student-teachers with laptops although they provided laptops for the full-fledged teachers. The pre-service teachers used the NIE laptop during their practicum. Steve switched to his own laptop after two weeks as the NIE laptop had crashed. Nicole used her NIE laptop to prepare her work, but for classroom lessons, she used her cooperating teacher's laptop (there were no desktops in the classrooms) as it was lighter and easier to carry around.

Although all the schools had Internet connection in the staffrooms and in the classrooms (Steve and Kenneth had wireless Internet connection while Nicole had to rely on LAN cables for Internet connection), Nicole and Steve faced problems with limited Internet access for various reasons. Nicole was told by her cooperating teacher not to use the LAN cables with her own laptop. This may be because quite often, personal computing gadgets are not sufficiently protected against viruses due to poor security implementation. The teachers in her school were strongly encouraged to bring their own wireless modem. The teachers in the school that Steve did his practicum in were told they could not use the wireless Internet access in the classrooms. Steve did not give a reason for this. Both Nicole and Steve were also not given access to the wireless networks of the respective schools they were posted to as they were trainee teachers. Not being granted full access to the schools' ICT facilities may have been a slight hindrance to the use of ICT in the classrooms.

Some schools had more ICT equipment and some had more support for the use and implementation of ICT in classrooms. All the classrooms in the school Steve was at were equipped with computers and ActivBoards.

However, there were also some other issues pertaining to the ICT infrastructure of the schools that the student-teachers faced while doing their practicum.

For Nicole, projectors in the classrooms did not work well and there were problems with the VGA (video graphics array) cables and sockets, so she ended up using the blackboard most of the time. Moreover, there were limited sets of visualizers in the school and the schools' laptops were very old so the document files had to be converted to a suitable format. She was also advised against using the computer labs to teach. There was generally not much technical support from the school. Nicole also mentioned that the school did not have the funds to buy anything related to ICT anytime soon.

Steve brought his own laptop to class but faced problems with displaying Chinese fonts accurately. He also found it troublesome to set up his laptop in the classroom. Teachers in the school were also not allowed to log on to social networking sites and the like. Some Chinese websites (e.g. qq.com) were also blocked from the school's network.

During his practicum, Kenneth brought in simulations, applets and videos for the classes as he believed it to be a hidden expectation for his practicum assessments. He used PowerPoint presentations and Civilization 4 to teach Physics. He also used TED and

other social networking tools to engage his class in discussions outside classroom time. He did not think sending emails to his students was a good idea as he said many of them did not check their mailboxes. He believed a tablet PC would be very useful for teaching as he could write whatever he needed on his tablet PC and then send it to the students. This way, the information could be stored and used again at a later date. With the whiteboards, the information simply disappeared when the board was erased. His Smartphone also came in handy when he could not find his mobile presenter and used an application on his mobile phone to substitute a mobile presenter. Also, in his opinion, ICT should be used with students who are academically stronger and for students who are not as academically inclined. He said that going through the "normal tutorial is good enough" for now as students who are less academically inclined take a longer time to grasp concepts. The physics department in his practicum school had a Facebook group, which was used for non-work related matters and this brought the people in the department closer to each other although they did not have much face-to-face communication.

Nicole used her laptop mostly for teaching-related matters as she said she had little time for "non-teaching stuff", although she did allow herself the occasional distraction on her laptop. In the classroom, she used PowerPoint presentations, videos, Wikipedia and crossword puzzles. She said she "did not have time for too many creative lessons" as she had to finish covering the given syllabus. She said that she faced time constraints as she was required to teach many things for the examinations and for that, she felt the most efficient method was frontal teaching. She thought PowerPoint presentations were good because they could be re-used. For her thirty-minute lessons, she also did not see the point in using her laptop as the laptop took a while to start up.

Steve used his laptop for preparing lesson plans and making changes to his notes/PowerPoint slides. In the classroom, he used PowerPoint presentations and tried to bring in computer games and "online stuff" for his Primary Five students. He said the classes were well-received. He did not do the same for his Primary Three class as he felt they were "too young for that". His belief about technology not being suitable for lower-ability students might be due to him attempting to force-fit ICT into traditional classroom methods and activities and these end up being ineffective as the introduction of ICT may have changed the dynamics of the traditional activities. New tools sometimes need to be complemented with new activities. He also used Flash to design a scoring program and a program for learning new Chinese words. He commented that Adobe Flash opened a lot of possibilities in designing teaching tools and new methodologies.

For their practicum, most of them tried to use other software and tools apart from PowerPoint presentations in their classroom teaching session, and found them to be rather useful. Nicole and Kenneth only did so because they felt pressured to or felt that it was a necessity. Although this is a form of adoption of laptop affordances, it is not a willing one. Steve was the only one who had gone to the extent of designing programs himself for his class and not just used whatever was available online.

6. A Summary of the Findings

Overall, there were some observations that stood out in the study. The surveys conducted show that ownership levels and usage levels for communication and media consumption were high, but the usage levels for content creation was significantly lower. However, even though the usage levels for communication and media consumption were high, the average time spent on these activities (in a week) was relatively low. This could possibly be because these pre-service teachers let some of these applications run in the background but only recorded the time spent more intensively on these activities. For teaching and learning, most of them commonly use about five of the ICT activities listed.

From the case studies, it can be seen that Kenneth and Nicole used ICT tools mostly on a need-to basis, and most of their ICT usage involved work. Also, Nicole's level of comfort with ICT tools did not seem to increase much with the increase in her level of familiarity with her ICT tools. This is contradictory to the results found in the study done by Resta et al. (2004), which showed that after a year of forced implementation, the pre-service teachers' attitude toward ICT tools changed for the better. Also, the student-teachers seem to only be scratching the surface of what ICT tools can be used for in the classrooms, and in their personal lives. The lack of ease and familiarity with ICT, and the student-teachers' general perceptions about laptops and ICT seem to be the main factors affecting the smooth transition of laptops into their classroom sessions and their lives. Also, they were sometimes not able to effectively manipulate the tools to suit their needs, and as a result, they viewed the tools as ineffective.

Mostly, the student-teachers seem to view the ICT tools as objects to enhance, rather than as a main tool in itself.

7. Conclusion

We live and work in an increasingly ubiquitous computing environment, and personal computing devices in education and learning have become more human-centered, less visible, and available to students whenever and wherever they need it (Norris & Soloway, 2004; Roschelle & Pea, 2002; van't Hooft & Swan, 2007).The ubiquitous, 24/7 access to computers makes it possible for students to access a wide range of resources to support their learning, to communicate with peers and their teachers, and to become adaptable in their use of the technological tools of the 21st century workplace. Today in most technologically advanced societies it is not uncommon for people to own more than one computing device. Although an individual has more than one device, he/she would only use one device at a time, switching between different devices to serve different purposes.

Seamless integration of technology happens when technology becomes a part of the pre-service teachers' lives, be it in NIE, their homes or in the schools they were posted to for their practicum. From the data above, it can be seen that although the quantitative data shows that general usage levels are high and ICT applications are quite widely used for teaching and learning, the case studies seem to show a dissonance between the usage of laptops/desktops for work and for personal use among the pre-service teachers.

Pre-service teachers from the case studies see the computer mostly as a work tool and even when they employ it for personal use, many of them only use it for a limited set of activities, and mostly do not seem interested in exploring much further than they have to.

According to Dwyer, Ringstaff, and Sandholtz (1991), teachers generally go through five stages in the process of incorporating the use of computers into their classrooms. The same model can be adapted and applied to gauge how well the student-teachers have adopted the affordances of ICT tools into their lives. The first is the entry stage, where the physical environment starts to change. Computers are placed in the respective environments and there are teething problems of using computers. Here, the tools used are still relatively traditional – pen, paper and books. The second stage is called the adoption stage. Here, there are fewer concerns about the connections and wiring of the laptop and focus on using the laptops but for traditional activities (new tools, old activities as mentioned above). There is little change in how things are done. The next stage is the adaptation stage, where technology is completely integrated into the respective environments and everyday tasks are "30-40 percent of the time supported with the use of word processors, databases, graphics, and computer-assisted instruction". The fourth stage is known as the appropriation stage. This is the stage where greater mastery and confidence is gained. Computers are now familiar ground. There is more collaborative learning and the traditional tools are used less. The last stage, also known as the inventing stage, the whole environment changes. Not only has the physical environment changed (first stage), but mindsets have also been transformed. This is the stage where new tools and software are created, instead of just plucked from the Internet or other sources.

From the survey data, it seems most teachers are possibly at around stages 2-3. Not many are in stages 4 and 5, as they do not engage much in content creation. Even those who do, spend very little time on it, on the average. From the case studies, it is noticed that Nicole seems to hover around stage 2 and Kenneth around stage 3. Steve might qualify to be in stage 5. All this information appear to suggest that there is still much room for improvement when it comes to using ICT devices.

8. Limitations of the Study

This study has a number of limitations. The data was collected via surveys and self-reportage (during interview sessions). Future studies could include personal observations or even "shadowing" of the pre-service teachers to achieve a greater in-depth study. A more comprehensive picture would be to include the usage of the various devices owned by the pre-service teachers. Nevertheless, the information collected in this study can serve to advise local policy-makers on the usage trends, attitudes and beliefs of student-teachers toward ICT. This adds to the growing body of knowledge in this area and can be very useful for future ICT implementations.

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