Article

Bridging the digital divide in a remote elementary school: A teacher's reflection on invisible work

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This case study presents my reflection as a teacher on the invisible work of initiating an instructional technology project designed to close children's digital inequality. Thirteen One Laptop Per Child (OLPC) XO laptops were funded by my dissertation fellowship and deployed to 2nd and 5th grade students in a remote elementary school in Taiwan. I taught these children science classes from June 2011 to January 2012 and recruited them to be my participants. Qualitative thematic analysis was employed and triangulation was used to analyze field notes, interview transcriptions, documents, and the children's usage logs. My field reflections throughout this qualitative case study revealed that invisible work was necessary in order to sustain, protect, and expand students' opportunity to use their XO laptops in the school. In response, I argue that public awareness about teachers' invisible work is critical and should be studied, reported, and recognized by the field of educational research.

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Background

This article presents my journey as a teacher in a remote school in Taiwan working to bridge the digital divide using XO laptops. I describe my participative presence as a teacher in the school to unmask the invisible work that made this project a reality. Treating this remote highland school as a bounded, particular, and complex entity, I argue that a holistic case study was appropriate to address my reflections. In this article, a particularistic, descriptive, and heuristic (Merriam, 1998) case is described, to assist in facilitating the understanding of the invisible work needed for a teacher to close the digital divide in a mountain school in Taiwan.

The digital divide in Taiwan's context

Technology access and training has been treated widely as a critical strategy to equip high quality, competent, and productive citizens. In Taiwan, the Ministry of Education (MOE) established the free Taiwan Academic Network (TANet) for higher education and research institutions in 1990 (Tseng, Su, & Chao, 1996). Although the first plan for promoting K-12 technology education was issued in 1989, the TANet connection to K-12 schools was not accomplished until 1999 by the National Information Infrastructure (NII) project. After infrastructure, curriculum, and teacher preparation were established, the *General Guidelines of Grades 1-9 Curriculum for Elementary and Junior High School Education* (2008) called for students "To acquire the ability to utilize technology and information" (p. 5). Under its section titled "Critical Topics: Information Technology Education," the guidelines required 32 to 36 hours of computer classes each school year for 3rd to 7th grade students. For 8th and 9th grade, the guidelines required academic subjects such as science or aesthetic education to incorporate information technology into disciplinary instruction and provide advanced computer classes as electives. While I was conducting my fieldwork, the *Monthly Bulletin of Interior Statistics* of Taiwan (http://sowf.moi.gov.tw/stat/month/m3-01.xls) reported there were 112,000 qualified low-income families as of December 2010, which represented 1.41% of the total households. The related *White Paper of Information Education in Taiwan* (MOE, 2008) admitted that even though Taiwan was ranked the seventh best country in a comparison of the digital opportunity index around the world (WSIS, 2007, p. 36), less than 50% of rural students had an opportunity to finish their homework assignments via computers. This phenomenon echoed the observation of van Dijk (2005), that even in the most developed high-tech societies, digital inequalities still exist and are deepening even though they may have stopped widening.

To shorten resource shortages, the Ministry of Education conducted follow-up initiatives to help rural communities close digital divides, including "I-tutors" (encouraged college students to become weekly volunteer online tutors of rural elementary school students), "College e-Volunteers" (MOE organized college service-learning students to conduct rural digital literacy workshops), "Laptop donations from IT firms" (urged local IT firms such as HTC, Asus, and Acer to centralize their donations of laptop and tablet products to MOE for efficient reallocation), "Citizen Desktop" (MOE provided 1,000 desktop computers annually to low-income households with elementary school children. Free and open source software was pre-installed in these desktops, as well as "Digital Opportunity Centre, DOC" (MOE established DOCs in rural libraries and village centers that provided internet access and computer classes). In addition to closing the digital divide for both children and adults, these projects have had positive influences on students who were digitally disadvantaged (e.g., see ChanLin, Lin, & Lu, 2016 on improving students' academic achievement via online tutors). However, some of the projects lack utilization of other policy instruments and subsequently diminished the effects. For example, the Citizen Desktop gifted computers and open source software to low-income families. However, the project did not fund the internet connection fee even though those families obviously cannot afford to do so. Moreover, the funding of DOC did not cover maintenance staff and caused the daily operation of centers difficult.

The need for investigating invisible work

In this study, one of my critical foci was the teachers' "invisible work," which brings the ideals of bridging digital inequalities into reality. Encouraging the study of teachers' invisible work benefits not only educational research, but also practice because teachers' contributions to education and society should not be underestimated and their demands for support should not be ignored.

Much work is invisible (Nardi & Engestrom, 1999) and has yet to be mapped, measured, or even honored. The concept of "invisible work" (e.g., DeVault, 2014; Forsythe, 1999; Kosny & MacEachen, 2010); "unseen work" (Lahiri-Dutt & Sil, 2014); "hidden work" (Goodyear & Ellis, 2008; Mayberry, 2016; Swinglehurst, Greenhalgh, Myall, & Russell, 2010); "informal work" (e.g., Biles, 2008; Ludermir & Lewis, 2005; Phillips & James, 2014; Whitson, 2010); or "hidden labor" (Gary, 2017; Kümbetoğlu, User, & Akpınar, 2010; Marquand, 2013) originally was studied differently by labor economists and sociologists. Labor economists distinguish formal/informal work based on taxable compensation or legal recognition, as well as classifying these activities as part of the formal/informal economy. Some of the "invisible work" was neglected in the past but was later identified and tracked due to social changes, such as caregiving, migrant labor, and volunteer activity. Throughout the process of legalization, undeclared work may become formalized and measurable.

To better understand the character of invisible work, economists developed new measurement methods, such as the discrepancy method, monetary method, and unobserved variable method (Koopmans, 1994). The general idea of these methods is obtained by subtracting all the known formal economic activities from the total size of the economy, thus revealing the quantity of the hidden economy and its work. However, the major disadvantage of these indirect approaches was that the quality of invisible work was unclear and did not provide detailed characteristics about the work. On the other hand, gender stereotyping of jobs has been well documented in North America for decades (DeVault, 2014; Kosny & MacEachen, 2010; Tuominen, 1994), where gender sociologists are not concerned about the market value of hidden work, but want to raise public awareness about these neglected, unpaid, unrecognized, and undervalued contributions of the labor that women engage in for households and families, such as care-giving to children and elders. For instance, scholars advocate adjusting social support systems so that caregivers not only do not experience unequal stress or overload (Biles, 2008; Ludermir & Lewis, 2005), but also their affective labor practices are visible (Sweeney & Rhinesmith, 2017).

In addition to viewing it as part of informal sectors of the economy, invisible work can be seen as the effort that an individual provides as extra work to his or her designated duty. More critically, informal work is essential to the successful functioning of formal work (Tuominen, 1994). Hence, ethnographically studying a specific context of work may shed light on the contributions of this approach. For example, McWilliam and Wong (1994) explored nurses' daily life experiences and found they needed to compensate for the weaknesses related to hospital bureaucracy and deal with fragmented tasks under high pressure situations. Unfortunately, such work is difficult to report by workload-measurement experts. Nilsen and McKechnie (2002) articulated the hidden work of librarianship—such as cataloguing and collection development—by interviewing patrons and librarians about the public images of librarians. Moreover, even a qualitative researcher devotes his or her efforts to many hidden roles and works as a collaborator, learner, teacher, reality shaper, and mediator in addition to research responsibilities (Stake, 1995; Thomas & Lambert, 2008). Moreover, Hockey (2004) depicted informal work that social science contract researchers engaged in to raise their possibilities of being employed by academic institutions. These studies not only helped readers rethink the images and stereotypes of a typical job, but also raised the awareness of these critical professions' contributions behind the scenes.

In educational contexts, the relationship between a particular intervention (input) and its consequence (outcome) is always depicted as a casual chain. However, researchers or policy makers may overlook the unseen work that teachers, students, parents, and others have to perform in the process, to make the intervention a reality (Goodyear & Ellis, 2008). In a technologically assisted science-learning project, researchers asked a critical question during research process: "How do we move from innovative research-led learning experiences to everyday teacher-led learning experiences in the classroom?" (Smith, Underwood, Fitzpatrick, & Luckin, 2009, p. 290). They realized invisible efforts may not fit into original research-led, task process and context, but were very important because they constituted the added efforts necessary to make the project work, especially when researchers transferred research outcomes to teachers. The researchers then identified the details of the hidden work that teachers participated in to make the e-Science happen in two schools. These activities included: (1) matching learning requirements; (2) creating or locating contextualizing materials; (3) building, coordinating, collaborating, and communicating relationships; (4) manipulating data; (5) managing equipment; and (6) testing, breaking down, and repairing (Smith, Underwood, Fitzpatrick, & Luckin, 2009; Underwood, Smith, Rosemary, & Geraldine, 2008, pp. 540-544).

Teachers perform many additional hidden/extra tasks, such as mentoring novice or internship teachers (Hamel & Jaasko-Fisher, 2011), assisting administrative routines, or leading community centers. However, such efforts may not be listed formally as their typical responsibilities. One possible explanation that teachers do so much invisible work is because they are expected to cover great breadth and depth in the endeavor of influencing society. Eventually, such role expectations result in being “considerably broader than its actual role” (Ferge, 1971, p. 21). Bhana, Morrell, Epstein, and Moletsane (2006) in Durban, South Africa described an unnoticed story about overwhelmed teachers who were exposed to danger and provided care to HIV-positive students in the community without any support and training from health professionals, social workers, or psychologists. This research echoes Ferge’s (1971) observation that teachers have limited capacities but are expected to overcome and succeed in tasks they were not prepared to do.

Myself: The teacher and researcher in the process of bridging the digital divide

As a graduate student claiming his specialty in educational technology since 2001, I did not realize my calling as an educator until about 10 years later. I studied at the University of Illinois at Urbana-Champaign and became acquainted with the OLPC laptop in a service-learning class at the Graduate School of Library and Information Science in 2008. I was inspired by the enthusiastic and ambitious charity project. Eventually, my calling to bridge the digital divide in the remote area of my hometown guided me to this small-scale deployment of XO laptops to the remote school children.

I obtained permission from Maggie, the principal of the school, in February 2011, to use her school as the research site from June 2011 to January 2012. Unfortunately, the school experienced a severe teacher shortage at the beginning of the new school year. Maggie tried her best but found no one to fill the vacancy. Finally, she asked my assistance, and I agreed to be a visiting science teacher for the fall of 2011 and to teach 2nd and 5th grade students. This fulltime appointment changed my role from an outsider researcher to an insider teacher-researcher in the school. In my journey, I found myself caring more about being a responsible teacher and a companion to students, parents, and colleagues, rather than being a researcher. I had thought I would collaborate with a schoolteacher who was interested in the OLPC project, and I would observe and document how a teacher bridges the digital divide in Skyline Elementary School. However, I became the change-agent (Rogers, 2003) who initiated the project by designing learn-with-XOs classroom activities.

My previous self-training in Linux allowed me to localize and customize the XO laptops for instructional purposes. I installed the Ubuntu desktop environment and made the XO dual-bootable. This extended the applicability of the XO laptops to children. Besides technology, I chatted with teachers to familiarize myself with the school routines and student backgrounds (2011/07/20, journal). For example, 5th grade students were considered highly motivated children among all other grades, and one 2nd grade girl had a slight physical disability with her legs. This information was valuable when preparing my instructions.

Stake (1995) described the compound characters found within the role of an educational researcher. This person can interchangeably take the role as an interpreter, a biographer, an evaluator, an advocate, and a teacher during research. My technological competences, knowledge of the academic discussions of digital divides and learning with handhelds, and personal experiences with XO laptops provided me with both theoretical and practical ground to initiate my research. As a flexible case-study researcher and a teacher, inevitably I contributed part of my time participating in the daily routine of the school operations as a volunteer and used my professions to maintain the school website and server, optimize and troubleshoot outdated desktop computers, provide small training sessions about useful education software, and so on. Moreover, my participative actions resulted in a better understanding of how things worked and what it meant in the research site. Throughout the actual engagement, a qualitative researcher like me reflexively negotiated myself within the social context by "learning to listen" and "listening to learn" (McIntyre, 2008, p.8). By working with practitioners, the stereotypical beliefs have a chance to be eliminated.

Research questions

Being a teacher, a change-agent of the digital divide in a remote school, and a researcher whose focus was invisible work in mind, I had two major research questions: (1) *What were students' learning experience with XO laptops in terms of van Dijk's four accesses* (motivational, material, skill, and usage)? Moreover, towards achieving the richness of learning with technology, (2) *What is the invisible work that teachers do to bridge the digital divide in schools?*

Methods

To me, qualitative inquiry is an engaging, situated journey for both researchers and participants. It is also an action of multiple interpretive practices (Denzin & Lincoln, 2005). Qualitative work not only provides possibilities for participants' perspectives and meanings to be articulated, but also enables us to understand ourselves in relation to the larger world. Researchers are interested in understanding the meanings that have been constructed by others (Merriam, 1998).

Study design

To discover the experiences of teachers' hidden work, regarding efforts towards closing digital inequalities, and the changes of remote elementary school students while learning with the XO laptops, this investigation was designed to be a qualitative case study (Stake, 1995; Merriam, 1998; Yin, 2009), because it explored a bounded and particular system and was intended to generate a holistic explanation, rather than to confirm or criticize pre-existing theoretical underpinnings. The following sections and Figure 1 show my research design.

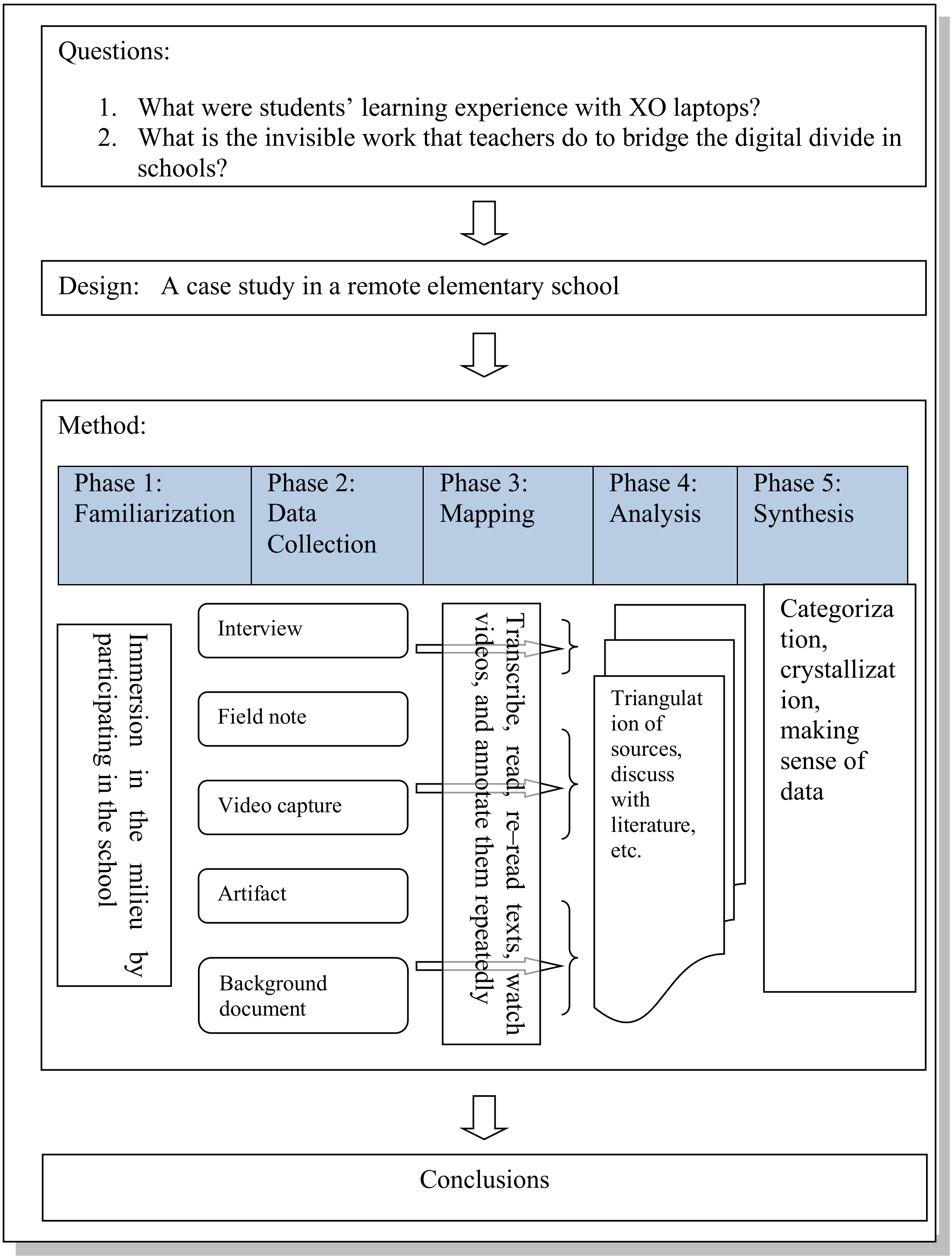

Figure 1. Research Design.

Study setting

Skyline Elementary School (a pseudonym), was located in the northern mountains of Taiwan at an altitude 3,937 feet (1,200 meters), near the south entrance of Shei-Pa National Park. MOE classified Skyline as an "extremely remote" school. To support remote schools in overcoming their disadvantages, the MOE initiated an action plan titled "Educational Priority Area" in 1998, which subsidized fewer-resourced schools such as Skyline with additional budgets for equipment, books, and extra teaching hours. This school was completely destroyed by an earthquake, measuring a 7.6 magnitude in 1999 and was rebuilt by a church fund in 2001. In 2011, there were 38 students from 1st to 6th grades, and 9 full-time, 1 substitute, 1 contract, and 2 aboriginal part-time teachers. The school district of Skyline contained two small tribal villages: Tian and Skyline. Residents in these two villages were mainly Atayal, one of the biggest ethnic Taiwanese aboriginal groups. Moreover, most of the children were raised by a single parent or by grandparents because adults needed to work out-of-town. Therefore, the elementary school not only served as the major site for cultivating and educating those resource-deprived children, but also as a community center in these two villages.

The context of Skyline was similar to two One Laptop Per Child (OLPC) local projects in western Australia (http://www.laptop.org.au/) and aboriginal Canada (http://www.olpccanada.com/), where students in remote areas of western Australia and aboriginal Canada still utilized the modern educational system with a complete, sequential, and required national curriculum, learning materials, and activities. Although learning opportunities in the remote area may not enjoy many resources like urban ones, students still had schools, teachers, curriculum, and local libraries. Moreover, an ICT infrastructure had been established at each school and there have been some, although not sustainable, government projects initiated to close inequalities. Under such context, XO laptops could play a supplementary role in developed countries rather than being the only learning media as in developing countries. To date, the OLPC project in Australia has delivered over 70,000 laptops to remote primary school children and established itself as a registered charity.

Supported by the government stimulation fund for remote schools, Skyline had a computer lab with 15 connected desktop computers and 3rd to 6th grade children had a 40-minute computer lab session every week to obtain some essential computer skills like using a mouse and a keyboard, English and Chinese typing, and word processing. However, only a few children had received and used desktop computers at home. Without the context of digital learning as part of life, the benefit of the current computer class was limited. Therefore, I decided to develop learning activities that focused on students' information literacy and motivation to use the XOs.

Research governance

I obtained both the approval of the College of Education Human Subject Review Committee (case number 4776, date March 30, 2011), and approval of the school principal in early February 2011 via e-mail communications. Prior to the start of the study, each participant was provided informed consent. Participants read, agreed, signed, and returned the consent forms to me.

Example instructional activities

Before fall semester began, I worked on developing 2nd and 5th grade course activities using the XO laptops (2011/08/21, journal). The 2nd grade students had no exposure to computers; therefore, the XO activities they experienced were mostly novel. For example, in an activity focused on developing the thinking process of categorization, I took students out of the school, paired then, and asked them to take photos of leaves with five different shapes using the XOs (Figure 2). After collecting enough photos, students described the differences of the found leaves and explained how they considered the similarities or differences among the leaves (2011/09/13, journal). Educational games were another alternative that I used in the 2nd grade classes. Some educational games in GCompris helped computational thinking and others facilitated spatial understanding (2011/09/21, journal).

Figure 2. Students Took Photos of a Leaf

Fifth grade students had some experience using computers. The advantage was that it was easier for me to jump to subject-area learning via the XOs. Moreover, they liked to use Ubuntu more than Sugar because that desktop interface was similar to Microsoft Windows in the weekly computer class. I was able to incorporate a few science learning activities using the XOs. For example, I twisted my left ankle at the end of September and could not walk with my spirited students. In one lab session, I gave students a worksheet, asked them to finish the activity using the XO and the piano on the third floor, and then come back to my office on the ground floor to debrief their findings (2011/9/26, journal). Using the Measure activity, the XO presented the shape of sound waves, and, therefore, students could examine the differences and draw the shapes. The worksheet asked students to compare the differences of the sound waves when they hit the very left and right side of the piano keyboard (Figure 3).

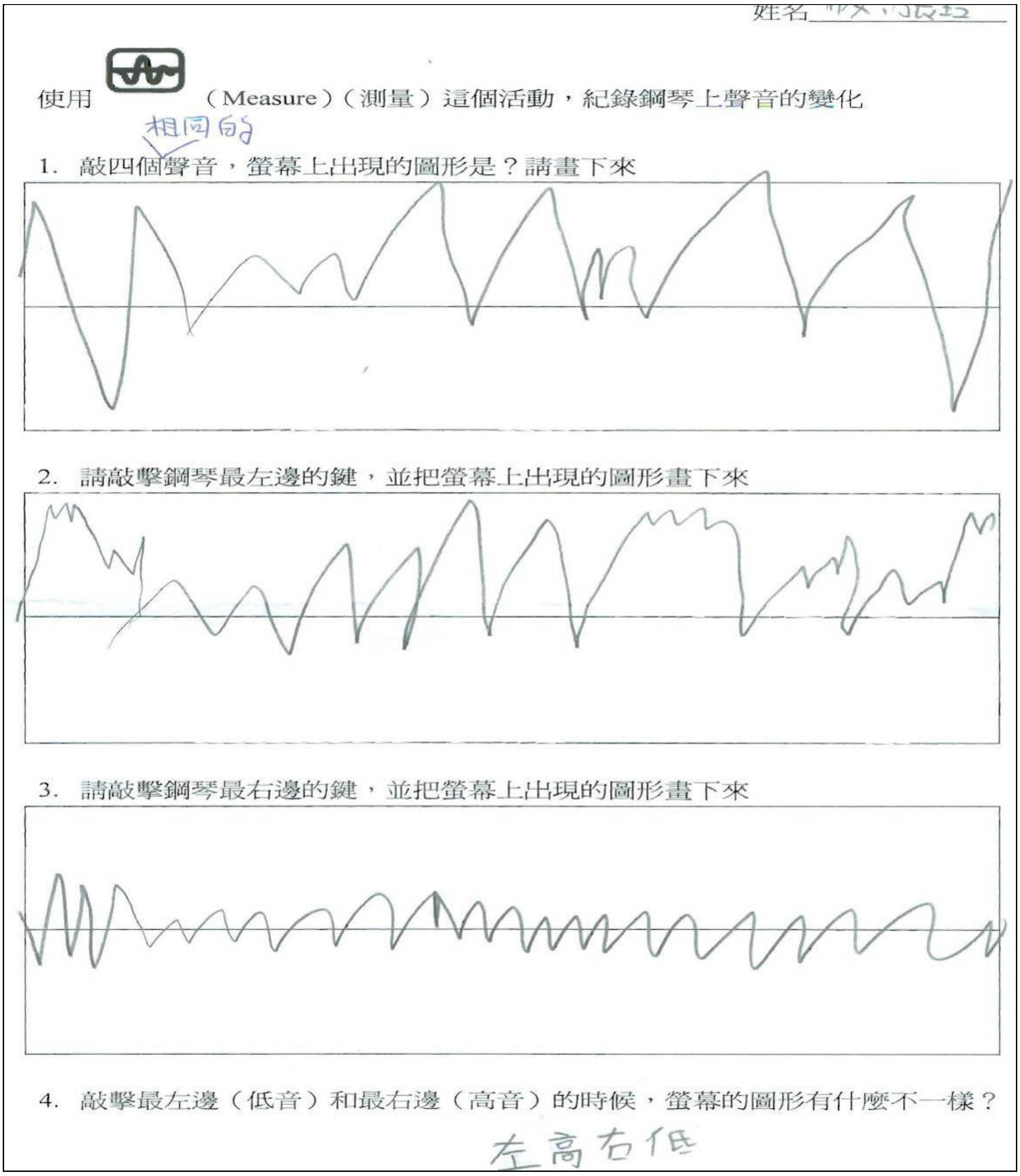

Figure 2. The Worksheet of Sound Wave Activity (2011/9/26, 5th worksheet)

Since 5th grade students can read longer texts, using an English-Chinese dictionary, searching community surroundings in Google Map, and finding pop songs on YouTube were introduced. I installed an e-book reader on the XO with some popular fiction selections such as Harry Potter for students (2011/11/07, class video, Figure 3). Later, I provided a small tutorial about searching and downloading fiction from websites where they could find stories of interest.

Figure 3. Steve Reading Fiction on His XO

XOs had collaborative functionality via the mesh network. I drove the 5th grade students uphill to the National Park where no wireless signals were available to interrupt XOs establishing mesh connections (2011/12/19, journal). The distance activity used the transmission time of a high-pitched sound to calculate the distance between two XO laptops. Students were amazed because they found their laptops could "hear" and "respond" with each other. This lab experience prompted their curiosity for further discussions about the measurement of long distances (e.g., between moon and earth).

Figure 4. Two Students Measuring Distances Using the XOs

Data sources and collection methods

This research project used data obtained through qualitative participant-observation, interview, and document analysis. The empirical data were collected in the following ways:

1. Classroom video/audio-tapes: There were observations during my class sessions. Each observation lasted 40-50 minutes. One video camcorder and two audio recorders were used. There were 208 recordings of my teaching sessions in the 2nd and 5th grades, which consisted of 1,471 recorded minutes (21.8 GB).
2. Photos: A digital camera was used by my students and me. The photos captured students' lives and learning during school hours (2,070 digital photos).
3. Interviews: There were student focus-group interviews, individual teacher interviews, and individual parent interviews. The students talked about their perceptions, experiences, questions, and feedback on the XO laptops and their learning experiences during or after class sessions. The teachers were interviewed about their experiences with XO laptops and perceptions of the changes made to the class at the end of the semester. Parents were interviewed about their perceptions and opinions of this XO implementation. Adult interviews lasted about 1-2 hours. There were 16 interviews, 689 minutes (7 students, 6 teachers, 2 parents, and 1 staff).
4. Field notes: I could not conduct data collection when I was teaching or responsible for administrative duties. Therefore, I took field notes and recorded my reflections daily each evening. There were 84 total daily journal entries.
5. Artifacts, document, and logs: Documents such as teachers' curriculum preparation notes, students' homework such as diaries and portfolios edited via XO laptops, students' exam sheets, the teacher-parents communication book, as well as the school's policy statement were read and examined.

Data mapping, analysis, and synthesis

Yin (2009) suggested three compositional structures in the reporting of a study: linear-analytic, chronological, and suspense that depend on the collected data and the choice of the case study authors. Considering that case study is a product of storytelling, Stake (1995, p. 127) suggested the development of the report should identify a biographical development of the case, how a researcher came to know the case, and a description of several major components in the case. Four analytic strategies (Yin, 2009, pp. 130-136) were used in my analysis: Relying on theoretical propositions; developing a case description; using both qualitative and quantitative evidence; and examining rival explanations. A codebook (e.g., see Crabtree & Miller, 1992) was developed and gradually revised as a template to induce the collected texts. QSR NVivo®, a qualitative data analysis software, was applied to help store, manage, code, categorize, and analyze my textual and pictorial-video data. Pseudonyms are used in this paper to protect the privacy of individuals and the school.

Through detailed note taking, transcribing, and reflective journaling, I developed my awareness of the most salient meanings of teaching and learning with XO laptops. Member checking with teachers and my contact also helped the correctness of data input, transcription, and my interpretations, thus illuminating potential biases. To verify the understandings of research, Lincoln and Guba (1985) suggested several criteria that improve the quality of qualitative research. Using multiple sources of data that provided corroborating evidence in my discussions, I triangulated the findings via data redundancy until representativeness and exhaustiveness could be confirmed (Holliday, 2007). In addition, evidence was addressed as coherent chains that contributed to the reached conclusions (Barone, 2004). Moreover, my prolonged engagement and persistent involvement as a teacher with faculty and students from 2011 summer to fall semesters, lent my fieldwork credibility. By appropriately citing these empirical data, the format "data generated date, data category-character or author" was used in the following chapters. For example, a quote from the interview of teacher QQ in January 5, 2001, was cited as "(2001/01/05, interview_QQ)" and my daily journal in September 05, 2012, was cited as "(2012/09/05, journal)."

Findings

Learning with the XO

In their 2015 article, van Deursen and van Dijk suggested that access to technology is successive in four sequential sections: motivational, material, skills, and usage access. In van Dijk's (2005) categorization, motivational access means the degree of willingness to be attracted by the ICT because some people are the "want-nots," not "have-nots." Material access indicates a necessary condition that proper devices, infrastructure, and supporting resources are provided and affordable to users. Skill access describes the user readiness of digital literacy like searching and evaluating information. Usage access argues the actual use of time and content in ICT. Therefore, easy to approach, easy to use, lower cognitive challenge, and cultural- and language-friendly content is critical to enabling technology access that bridges the divide. In this section, students' learning experience with the XO laptops, and how their technical competencies were improved, are described by van Deursen and van Dijk's four types of access.

Motivational access

Second and fifth grade students were highly motivated to use their own XO laptops. When I first distributed the XOs to 2nd grade students, I told them that they were encouraged to bring the laptops home and share them with family members. Although I did not have time to teach them on the first day of school, children figured out about 10 activities and started to play with the computers at home. I observed that they tried the maze, recording, browser, calculator, and speaking activities after just one night (2011/09/01, journal). Particularly, they expressed a sense of ownership with XOs because of its child-centered design. Students told me with excitement that the color and the shape of XOs differed significantly from teachers' for-office-use computers (2011/10/13, 1st exam sheets). For example, Steve, a 5th grade boy, commented that he felt that adults' computers were cold and designed for work purposes; however, his XO was more fun. To go further, I used two sessions in both grades and instructed students to decorate their XOs using colored pens and stickers (2011/09/02, journal). This personalization not only helped them identify their own laptops more easily but also improved the children's sense of ownership. Additionally, XO laptops brought different impressions to parents. After teaching my children for about six weeks, 2nd grade students started to tell me that their parents were thinking about buying them a real computer when they go to the junior high school (2011/10/03, journal).

During the last classes, I distributed a worksheet asking students how they would take care of their "little greens." Calantha wrote that: "*I will feed my little green, clean it every day, and won't let other classmates break it*." Nancy described her XO with personification saying: "*I will keep my little green clean, feed her, and put her in her home. Moreover, I will bring her to take a walk, bring her to jogging, play with her, and sleep with her. Oh! I want to bring my little green to the parks and see the flourishing flowers together!!*" (2011/12/26, 3rd exam sheets). Callia, a 2nd grade girl, said to me: "*When I am a 6th grader, I will give my little green to my younger brother; therefore, he can use it, too!!*" (2011/12/06, Callia & Calantha interview). Although I knew some comments were not realistic, (e.g., getting a laptop as a gift to junior high school), students showed high motivation in owning, using, taking care of their laptops.

Material access

Child-ownership and saturation is one of the key aspects for which OLPC Foundation advocates. In my study, students owned their laptops from day one and continued to use them even after I left the field for couple of months. The proper software installation and localization enabled students to use the XOs as learning tools. Second grade students felt their XOs were smaller than adult computers, were light-weight so that they could carry them home, had adorable ear-shaped wireless antenna, and colorfully designed covers (compared to adult black-or-white computers) (2011/10/13, 1st exam sheets). Moreover, the children enjoyed playing games and listening to pop songs on their XOs (2011/12/06, Callia & Calantha interview). Nancy liked the keyboard because it just fit her fingers (2011/12/06, Nancy & Yen interview). Students' usability feedback showed that the XO laptop was designed to meet learning needs of elementary school children.

Skills access

After optimizing and tweaking, I provided two computer-learning experiences for children: Sugar, the designated graphical environment developed by OLPC, was a place for children to explore surroundings (e.g., "Measure Activity") and produce ("Drawing Activity") in the real world; the Ubuntu environment connected children to the current GUI and desktop-based virtual world. The skills they learned such as searching for pictures via Google and then changing desktop wallpapers can be transferred when they use Windows or Mac computers. Evaluation of students' technology skills were formatively conducted during class instructions. For example, 2^{nd} grade students demonstrated their knowledge of how to search and listen to their favorite songs on YouTube. Fifth grade students gave me sophisticated answers about the reasons for learning to use computers. In terms of troubleshooting, Lydia replied that she learned the correct steps of shutting down her XO and the command of "disk check" if her XO failed to boot. Moreover, since Steve had more opportunities to get involved with computers, he asked for individual instructions when seeing me disassembling the broken XOs. Yuri compared different browsers that I installed and concluded Firefox was her favorite (2011/10/13, 1^{st} exam sheets). Alternatively, Yuri expressed interests similar to Steve in that she also wanted to learn how to repair the computers like me and expected this skill may help her earn much money when she grew up (2011/12/26, 3^{rd} exam sheets). Second grade students showed promise by using their own laptops and developing technical skills too. They took lively photos at home. Patty used her XO to take photos of her family in their bedrooms, and Yasmine played her XO with her sister Jaimie and shared her introduction videos with family members. After I taught students how to search via Google, the usage log revealed that Yavonna, another 2^{nd} grade girl, downloaded pop music in her XO and played it at home.

Usage access

When students first received the laptops, they were extremely excited and wanted to find something to play even before I said a word (2011/08/31, journal). They took time after my class sessions to explore the educational applications and web content. Lydia, the 5^{th} grade girl, told me that she witnessed Patty and other 2^{nd} grade students playing their XOs in the reading corner of the classroom during breaks (2011/12/01, Lydia interview). When they were back home, young children played educational games, took photos, charged the batteries, played music, and drew pictures with brothers and sisters (2011/11/25, 2^{nd} exam sheets; 2011/11/30, journal). From the usage log of the XOs, I retrieved Hattie's recording a story telling about her sister, and Callia danced with her brothers. According to the logs, Callia continually brought her laptop home and shared it with her two younger brothers until the end of semester. They were eager to learn information on the internet, and the "little greens" were a bridge for them to the resources they needed (2011/11/24, 2^{nd} exam sheet). Lydia, a 5^{th} grade girl, also mentioned that the most useful thing for her was using her XO to search for anything that felt foreign to her (2011/10/13, 1^{st} exam sheets). Steve pointed out that he liked to search images online and decorate his desktop background (2011/10/13, 1st exam sheets). Tammy liked using her XO to read children's fiction (2011/12/26, 3rd exam sheets).

The invisible work

To make my students' learning activities with their XOs a reality, many tasks were carried out before, during, and after my regular teacher role in this study.

Creating and locating contextualized learning experience

Because not all online resources are educational and meet the needs of appropriate age groups, instructional transformation was a critical task for me when implementing XOs in the rural school. It was all about translating information to teachable and learnable digital materials. In order to design course activities that meet students' learning needs, I consulted with senior teachers to understand students' entry behavior in each grade as well as the contexts of students' family and community. Using reflective journals, I took notes about my teaching and students' progress to refine and adjust learning activities gradually. My teaching and learning with the XOs can be classified into two parts: (1) learning to use XOs, and (3) learning through the XOs. The former was the introduction of functionality and embedded features in the laptop, and the latter leveraged XOs as technological mediums that facilitated exploring the world. Within the pre-defined curriculum, some of the content can be taught via the XO activities. I had intentioned to give more structured, discipline-based instructions to 5th grade students while giving freedom for 2nd grade students to explore their own laptops (2011/09/01, journal).

Building relationships with students, staff, and community

The most important proportion of my hidden effort in this study was maintaining a good relationship and unobstructed communication among administrators, teachers, parents, and even students. I built an initial relationship with Maggie by agreeing to help wherever she needed me. I conducted a number of additional tasks, such as: smoothing administrative routines (2011/06/27, journal); conducting family visits (2011/07/21, fieldnote); programming an e-document processing system (2011/06/29, fieldnote); acting as a commute driver (2011/07/25, journal), an IT technician (2011/11/17, interview_Chris), and a substitute teacher for those who had applied for sick- or business-leaves (2011/09/15, fieldnote); and even being a maintenance staff who helped fix the tap-water system (2011/08/16, journal). Because of these volunteering experiences, Maggie and other colleagues gradually trusted my presence in the field.

The school provided dormitory rooms for students and teachers during the weekdays. Before their evening study session, I played chess with students or joined their recorder practices using my flute. Students were excited because it was interesting that different instruments could be played together (2011/12/13, journal). Aaron, one of the aboriginal teachers, shared his observation that teacher-student relationship was typically close in boarding schools. However, in Skyline it "*looks like that the two groups of people are strangers!! Only if, when you are the one who needs to be responsible for the evening study session from 7:00 pm to 8:30 pm. Otherwise, they don't want to even talk to students in the hallway*" (2011/12/05, Aaron interview). During my fieldwork, I usually stayed in the school for an hour after dinner. Most of the time, only Yanaba, the dormitory manager, and I ate with children in the dining room, and we had students talking about their school day or sharing their family stories.

Managing infrastructure, equipment, and resource

One of the invisible routines that technology-assisted classroom instructors must do is resource and infrastructure management, such as scheduling equipment, troubleshooting technology infrastructure, and managing hardware and software resources. I installed a wireless router that covered the instructional building, allowing XO laptops to be connected. Instead of storing laptops in the school like many school technology projects do, I permitted and encouraged students to bring and use their XOs at home. Students gradually learned how to take care of their belongings. To support my decision and prepare for possible hardware defects, I bid on two broken XO laptops from eBay and used them for replacement parts. To fulfil my needs to teach and research my students, I occupied an unused room as my science lab (2011/08/28, journal). I rearranged the space, cleaned the room, wired the extension cords, installed a wireless router, and moved my teaching materials and research equipment in this room. To sustain the project, I wrote a grant proposal to Quanta Charity Foundation[1] to seek a possible sponsoring opportunity on behalf of the principal (2011/03/02, personal communications-Julian; 011/04/16, personal communications-Julian).

Testing, maintaining, and troubleshooting

Before I entered into the field, I connected myself to the related OLPC technicians and community forums to obtain necessary support such as localization and educational software. The installation and testing were completed before the semester started. Moreover, I self-learned over the internet and was able to be the XO repairperson on the fly during residency. This ensured any technical problems could be resolved quickly so that children's learning was not interrupted. Although I tried to train one of the 5th grade boys with a few basic skills to resolve common system errors, it was unsuccessful.

Being flexible and positive

In addition to all of the above identified types of invisible work addressed by Underwood, Smith, Rosemary, and Geraldine (2008), two important characteristics that a person needs in order to deploy technology remotely are flexibility and positivity. During my

[1] An affiliated charity organization under Quanta Inc., the contract manufacturer of the XO laptops.

residency, many events deprived students' hours of learning (e.g., mayor's visits, charity donation ceremonies, field trips, sport meets, and even immunizations and dental services). Moreover, a few other teachers banned the use of the XOs because they viewed laptops as gadgets rather than learning tools. I needed to work constructively to sustain my XO-embedded instructions. Another unexpected situation I faced was the serious conflicts between administrators and young teachers. I needed to stay neutral between both sides and be helpful to everybody (2011/11/08, journal).

Unlike some researchers who might choose another "safe" research site, I decided to stay and overcome the challenges. I applied the "helpful good guy" strategy (Van Maanen, 1988) most of time during my residency. I noted "overwhelming" in one of my reflection journals due to the interplay as a teacher, technician, colleague, volunteer, and researcher (2011/09/02, journal). Taking field notes and maintaining reflective journals were helpful to me in coping with loneliness and clarified my primary role as a teacher to my children. Managing a vigorous but flexible attitude during implementation helped sustain the project. The "mental and emotional" invisible work that balances certainty and uncertainty is a necessary characteristic that every change-agent (Rogers, 2003) needs to overcome. Being positive and flexible was my tenet to move students' learning forward. I also believed a field study should be mutually beneficial to both the researcher and the research site. Therefore, I tried to maintain friendships with both sides to prevent my XO project from being dismantled due to the conflicts.

Concluding reflections

Many key factors drive success of community informatics projects, such as maintaining social harmony (O'Neil, 2002), creating institutions of caring (Sweeney & Rhinesmith, 2017), and empowering community members (Dolniˇcar & Fortunati, 2014). This is a journey of confessions about how I appropriated myself as a researcher and teacher in the field. In his *Tales of the Field*, Van Maanen (1988) used "confessional tales" to describe research work that draws on the human quality of a fieldworker and her or his self-reflective genres. The role of a fieldworker is not one of a passive or unremarkable person who simply stands or walks around and waits for something to happen. Instead, a confessional narrator is a visible actor in the field and tells of his or her involvements and interactions with the field. For me, being a teacher was a turning point that deepened my involvement in bridging digital divides in the school. I established my teaching spaces, negotiated my teaching assignments, communicated my teaching needs to colleagues, and talked with parents because the faculty role legitimized my presence in the school. The role not only enabled rich data collection, but also helped build close relationships with students and parents. This invisible work and coordination supported my actions to bridge the digital divide.

Many technological changes in the school, such as my actions that brought the XOs to the children, are not impossible, but can be difficult. Coping with existing conditions while arranging useful resources can be exhaustive to change-agents. Future research about teachers' invisible efforts is vital because their actions compensate structural deficits (McWillian & Wong, 1994). Their effort is a significant part of the teaching professions (Nilsen & McKechnie, 2002), is key to the functioning of formal activities (Touminen, 1994), and requires serious public attention (Goodyear & Ellis, 2008).

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