



Analyzing the Evolution of a Digital Technology Intervention: One Laptop Per Child in a Remote Papua New Guinea Community

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This article offers an ethnographic account of the evolution of a One Laptop per Child intervention program in Oksapmin communities (Papua New Guinea). The analysis examines the intervention's evolution as historically contingent, revealing how interdependent actions of multiple stakeholders create and partially resolve perceived threats to the program's continuation under changing circumstances. The approach contrasts with those that explain the success or failure of interventions based upon "fit" to cultural context. [Papua New Guinea, technology, educational intervention, schooling, One Laptop per Child]

Educational resources for schools vary dramatically in the "developed" as compared with the "developing world." The disparity is particularly stark when the focus is on communities in poor nations that are remote, communities in which shipping costs for books and materials are prohibitive, infrastructural supports for schooling are poor, and educators with substantial training are few (Winthrop and Smith 2012). To address resource scarcity, non-governmental organizations (NGOs) and local governments conduct educational outreach programs, some of which involve the distribution of low cost laptop computers, software, and peripherals. Despite their promise, such interventions involving digital technologies in remote sites have met with limited success (Cristia et al. 2017; Kraemer et al. 2009; Ozler 2012; Toyama 2011; Warschauer and Ames 2010). To date, we lack conceptually grounded approaches to understanding the dynamic evolution of interventions that can support an understanding of more and less successful outcomes. For the most part, interventions are treated as if they were static objects inserted into a community, with success or failure associated with how well they fit with extant conditions (Leaning 2010), such as lack of preparation of local educators to make productive use of digital media (James 2013; Warschauer and Ames 2010) or incommensurability of local instructional practices and the instructional approaches that digital media best afford (Villanueva-Mansilla and Olivera 2012).

This paper presents a case study of a One Laptop per Child (OLPC) program, a digital intervention introduced at a remote site in a mountainous region of Papua New Guinea. In our efforts to understand the intervention's evolution, we adopt a *process approach* that is grounded in the assumption that an intervention does not exist apart from the interpretive and material activity of participating individuals often in interaction with one another (see Goodwin and Duranti 1992; McDermott 1993 for similar treatments of context). Thus, we understand the evolution of an intervention at a local site as inherently unpredictable and historically contingent; as conditions for actions shift, the evolution of the intervention may take on new directions. Our approach requires a longitudinal method of research that considers the ways that the actions of individuals in the context of evolving conditions lead to alterations in an intervention's trajectory.

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To understand the trajectory of the OLPC program at the remote Papua New Guinea site, we focus on a series of emergent threats to the intervention in Oksapmin communities, with particular regard for how actors contribute to and/or manage those threats. This contextual focus allows us to identify sources of the intervention's vulnerabilities as well as the community's persistence in moving the intervention forward. The contextual focus also allows us to illuminate ways that local resolutions of perceived threats shape the intervention's emergent trajectory.

Some Context: One Laptop Per Child in a Papua New Guinea Community

One Laptop Per Child (OLPC), the focus of our analysis, is a well-known movement that has been at the forefront of digital technology intervention efforts (Negroponte 2007). One Laptop Per Child's vision is to bridge the "digital divide" by creating inexpensive but durable devices that can be used in remote parts of the world. The devices include OLPC's construction of a rugged "XO" laptop computer, a device with built-in connectivity and dedicated SugarTM software and auxiliary hardware, including servers, solar panels, and storage batteries (Buchele and Owusu-Aning 2007). OLPC sells the hardware to national governments and nonprofits; in turn, governments and nonprofits administer the distribution of the XOs and often provide support for their use. XOs have been appropriated in large quantities—over 2.4 million XO laptops have been distributed worldwide to students and teachers in countries in South America, Africa, Asia, Micronesia, Melanesia, and others (OLPC 2015).

The site for our analysis is the Oksapmin area, located in the western highlands area of Papua New Guinea in Sandaun Province. In many respects, Oksapmin communities present a potentially illuminating case for understanding the dynamics of an intervention's evolution in remote sites. Western contact with Oksapmin communities is relatively recent, with a first patrol making contact in 1938 (Gammage 1998) and the arrival of the first missionaries in the early 1960s (see also Macdonald 2013; Moylan 1981; Saxe 2012; Weeks 1981). The area remains remote, with no roads that connect the area to other parts of Papua New Guinea, though the first community school was established in 1967 as a joint venture between the government and the Australian Baptist Mission. Like other remote areas, the presence of primary schools provided sites for OLPC implementation in the community.

The selection of the three Oksapmin schools as sites for the OLPC pilot program reflected the advocacy of the Baptist Union, the national organization representing the Baptist denomination in Papua New Guinea. The selection of the Oksapmin schools was the direct result of a lobbying effort by an Oksapmin man who was a member of the Baptist Union. He lobbied the Papua New Guinea Sustainable Development Program (PNGSDP), a national funding organization for infrastructure projects and social programs, proposing an OLPC pilot program in the three Baptist Union administered schools. The three BU schools are separated by about a one-half day hike on a trail with deeply muddled sections. The four other schools in the Oksapmin area that are not administered by the Baptist Union did not receive OLPC technology.

The OLPC laptops (XOs), solar panels, and other OLPC material resources arrived in the Oksapmin area in August 2010. Figure 1 contains photographs of (a) XO laptops connected to portable solar panels and (b) solar panels powering XOs that are inside a classroom. The hardware was stored and prepared for use at the Baptist Mission station and then distributed to the schools several months later.

Our Investigative Approach

We visited the Oksapmin area in the summer of 2014, four years after the OLPC technology arrived. Before we arrived, we prepared for our fieldwork by drawing upon two key sources. First, to provide us a preliminary orientation, we reviewed our communications with an OLPC consultant who had described in some detail the material artifacts (XOs, solar panels, servers) that had been distributed to Oksapmin as well as the implementation effort. The consultant also provided the name of an Oksapmin school headmaster who was engaged in OLPC activities in Oksapmin. Second, we reviewed our prior ethnographic work conducted in Oksapmin communities in 1978, 1980, and 2001 (described in Saxe 2012); this body of fieldwork documented traditional knowledge forms (like the indigenous twenty-seven body part counting system), the use and alteration of traditional knowledge forms in collective practices of economic exchange and schooling, and a shift away from colonial styled schooling during the 1978-2001 period. In our fieldwork, we planned to build upon personal relationships established during earlier visits but now with a focus on the OLPC program.

We planned three kinds of ethnographic techniques to support our inquiry. The first was participant observation: direct observations of and conversations with Oksapmin people involved in the OLPC program, with a particular focus on headmasters and teachers. We were particularly interested in the character of people's knowledge in use of the XOs as well as people's ways of conceptualizing and understanding the successes, challenges, and difficulties with the OLPC program since its inception. We also planned to focus on students' participation with the XOs, but upon our arrival we learned that students were dismissed for a school vacation.

The second technique involved analyses of archival records. We consulted reports written about the initial implementation of the OLPC in Papua New Guinea (e.g., Leeming 2012), OLPC, produced materials (<https://one.laptop.org/>), and histories of the community (e.g., Macdonald 2013; Moylan 1981; Saxe 2012). We planned to identify additional sources in the course of our inquiry, and several useful sources emerged, including video documentation of the initial OLPC orientation and training effort (Lawrence 2011), and information concerning the nationalization of PNGSDP and the resulting cessation of funding for its programs, including the OLPC program.



FIGURE 1. Examples of (a) thin-film solar panels and XOs, and (b) thin film solar panels used to power XOs inside a classroom (Source: https://wikieducator.org/OLPC_PNGSDP/Kisap).

The third technique was communication with people who were not currently in the Oksapmin community but otherwise engaged with the OLPC program. We made contact with a technical adviser employed by PNGSDP, a technician responsible for maintaining the XOs and solar panels from Kiunga, a town reachable by a two-hour small plane ride from Oksapmin. We also contacted a 2010 volunteer who supported workshops for Oksapmin teachers shortly after receipt of the XOs and solar panels in the Oksapmin community. These off-site interactions illuminated our understanding of the web of interwoven activities on site.

Upon our arrival in Oksapmin, we began our fieldwork by contacting headmasters and teachers involved with the OLPC program at the three school sites. Our initial observations and discussions revealed school site differences in the quantity of XOs and solar panels; yet, despite marked differences in resources, there was limited use of the XOs at each site. These observations of limited use came to frame the guiding question that organized our subsequent inquiry: What was the trajectory of the OLPC program within and across sites that resulted in limited use across school sites? We realized that there could be any number of answers. For example, the simplest would be that the lack of use had existed from the 2010 inception of the program. However, we had reports from any number of sources that this was not the case—that at some points students and teachers were engaged with the XOs in productive ways.

We knew that an adequate answer to the question would involve understanding the complex set of actions and interactions distributed across individuals at different sites related to use of the XOs and peripherals, and the multiple opportunities and challenges involved with the new technology in a remote world. Through our inquiry, we came to understand that stakeholders identified numerous threats over the OLPC program's history and that some made concerted efforts to address these threats. We operated with the belief that, consistent with our process-oriented approach, to understand the trajectory of the OLPC program at each site, we had to inquire into the character of these threats to the intervention's viability and how these threats were managed through the program's history. We expected that our investigation would reveal that different historical trajectories had led to similarly limited laptop use across sites.

Emergent threats and their management

Through our methods, we identified five sequential threats to the development of OLPC that occurred during the 2010–2014 period. Consistent with our process treatment of the OLPC intervention, we defined “threat” as a set of circumstances that an individual interprets as a risk to the continued use of OLPC technology in teaching and learning.

We recognize that a threat to the continuation of OLPC may be conceptualized in different ways. For some, the OLPC technology was understood as an important development for the community, making such threats to OLPC technology use undesirable. For others, the OLPC technology was understood as a problem for the community, making such threats desirable. Further, some felt strongly about the technology, negatively or positively, and worked to engage others in like interpretations. In our analysis, we consider the actions of individuals in their production and/or interpretation of emergent threats. Of particular interest is the way that threats resulted in partial resolutions, setting conditions out of which trajectories of the OLPC program emerged at sites.

Our analysis traces five sequential threats that participants identified and attempted to manage. These threats include: (1) the initial introduction of XOs into a remote community in which computers were alien to most adults, teachers, and children, and people's

lack of familiarity with the computational media, which could have led to immediate program failure; (2) a subsequent distribution of the XOs in the community that aroused religious concerns, according to which XOs were a source of evil and foreboding, leading parents to hold children back from school, and could have resulted in an abrupt dissolution of the program; (3) a OLPC vision of transferring ownership of the XOs and peripherals to children to empower them, a threat that led to the disappearance of a great many XOs from children and schools; (4) the resignation and subsequent re-assignment of individuals to headmaster positions at OLPC schools, a threat that led to downward capacities to sustain OLPC programs; and, finally, (5) the government’s nationalization/ appropriation of the PNGSDP funds, a threat that led to a termination of professional support and ended the possibility of additional and needed XOs in the community.

Figure 2 contains a timeline of key events (lower part of figure) as well as the five identified threats to the program (upper part of figure). For each threat, we begin by providing background information that helps explain why and how the threat emerged and how it came to be managed. Through this analysis, we demonstrate how the process of threat emergence and management/partial resolve captures the complex, contingent unfolding of the OLPC program in the Oksapmin area and illuminates the outcome we observed in 2014. In so doing, we offer a case study that exemplifies the explanatory power of a process-oriented approach in capturing the evolution of a digital technology intervention in a remote community.

Threat #1: Computers Alien to Most in the Community

For most Oksapmin people, computers were alien prior to the OLPC program. The introduction of the XOs into the community thus faced the initial threat of no uptake.

Background. Initial Western contact with Oksapmin people occurred with a 1938–1939 Australian patrol, and the first missionaries arrived in the early 1960s, and with them the clearing and leveling of an area that could serve as a dirt landing strip for single engine aircraft (Gammage 1998; Saxe 2012). Today, there are still no roads to the area.

Western electric powered technologies have been slow to enter the Oksapmin world. In the 1970s, the Australian Baptist Mission Station imported a gas-powered generator, suitable for running refrigeration; in the 1980s, a few of the many small trade stores that

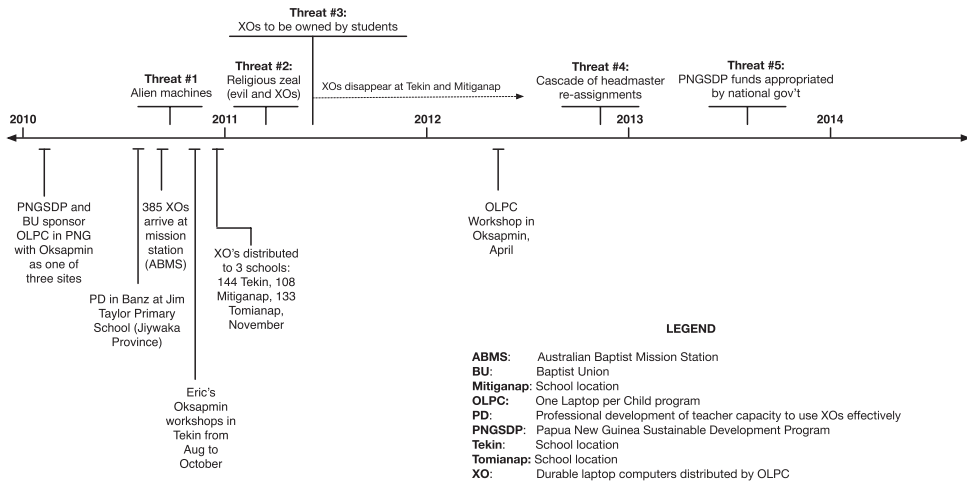


FIGURE 2. Timeline of key OLPC events and five identified threats to the OLPC program.

had been established by local people acquired generators that supported the use of refrigeration (for sale of items like frozen chickens).

In the 1960s and 1970s, there was little travel by Oksapmin people out of the Oksapmin area. The travel outside Oksapmin that did occur consisted largely of Oksapmin men’s trips to distant plantations and mines for stints of work. Subsequently, some Oksapmin adolescents pursued higher education in other parts of Papua New Guinea, where they encountered electric powered technologies. Some of these people returned as teachers. In 2005, a Baptist high school was founded on the Tekin primary school grounds.

The first digital technology that became available to many in the community was the cell phone (though calculators were used by some trade store owners at least as early as 2001). In 2011, a cell phone tower was built on a mountain pass in the Oksapmin area, and cell phones were brought in from outside the community and proliferated among Oksapmin people. Cell phones have become a technology that replaced traditional means of communicating across distances, such as “calling out,” serial word of mouth, and travel by foot.

The challenges to the OLPC program were many. The uninitiated user, whether a teacher or a student, faced a steep learning curve to use an XO to serve elementary functions. First, there are fundamental ontological questions: What is this? Is it a toy? A magical machine, a divine creation (or an evil one)? Second, there are the more instrumental questions pertaining to hardware: how to open the computer (which is not straightforward), turn on the computer, or power the computer with solar panels and connecting wires. Third, there are questions that pertain to the software: understanding the idea of an application (or as these are named in Sugar, “activities”), the functionality of any one of the many activities, and how to navigate across activities. Fourth, there are challenges that are specific to teachers that involve new forms of pedagogy: what activities to privilege in relation to a curriculum and how to use the software in productive ways, whether in whole class instruction or individual activities or in small group work. Fifth, there are issues of support: With so little technical knowledge in the community, whom can one turn to for support when something goes awry?

Management of the Threat. Efforts to manage the threat occurred both outside and inside the Oksapmin world. Sometimes management efforts were planned and organized; other times they emerged on the spot in efforts to accommodate local challenges.

Management from Outside. PNGSDP, the sponsoring organization, was aware of the import of supporting local school capacity to implement the use of laptops. PNGSDP contracted with an educational advisor, DOL to support the implementation. DOL organized a workshop for the three school sites targeted by PNGSDP to occur in July 2010 at the Jim Taylor Primary School in Banz, a small community about a 1-hour drive east of Mt. Hagen, an area only accessible by plane from Oksapmin. Table 1 contains the pseudonyms, titles, and descriptions of key individuals to whom we refer.

PNGSDP Advisor’s preliminary Oksapmin visit. Prior to the workshop, the advisor had made a preliminary visit to Oksapmin and met with HAT, the headmaster at Tomianap Primary School. HAT agreed to take on the responsibility as the Coordinator of OLPC for the three Baptist Union schools in Oksapmin. Initially, HAT had limited knowledge of computer use, but his knowledge grew with engagement with the OLPC program. He became an advocate of the program and believed in the potential utility of the XOs

to support education in the Oksapmin community. Table 1 contains a profile of DOL and HAT and other stakeholders to whom we refer in our analysis of the five emergent threats.

In Oksapmin, DOL also met a volunteer at Oksapmin High School, VEM, and his wife. The son of a missionary from the Summer Institute of Linguistics (SIL) who resided in the Oksapmin area for 14 years, VEM was raised in Oksapmin. By the time he returned as a volunteer, VEM had developed skills in computational technologies. VEM became an important resource for the development of the OLPC program. But his volunteer residence was temporary – his stay was for only a year, ending in November 2010.

The training session in 2010. DOL organized a one-week training session at Jim Taylor Primary School in Banz attended by HAT and VEM. The workshop covered a range of topics related to the operating of XOs, including basic laptop skills, using Sugar activities, accessing and using the server, and lesson planning with XOs (for an observer's reflections, see Hosman 2010a, 2010b, 2010c). At the workshop, as part of their own training, teachers were also teaching students. VEM is shown in Figure 3 at Banz assisting with teacher training and himself becoming trained as an OLPC teacher trainer. HAT was also

Table 1.
Stakeholder Pseudonyms, Positions, and Descriptions of Their Relation to OLPC in Oksapmin

Stake-holder	Position(s)	Description
DOL	Advisor/consultant to PNGSDP for OLPC implementation	2010. DOL ran the OLPC teacher training in Banz in 2010. He visited Oksapmin, providing a supportive role and ran a follow-up teacher workshop for a brief period
VEM	Volunteer at mission station in 2010	2010. VEM served as a volunteer at the mission for a 1-year period. VEM had knowledge of digital technology; he volunteered to run a regular workshop for teachers/headmasters at Tekin until his departure in late, 2010. He also attended the teacher-training workshop in Banz
HTE	Headmaster at Tekin School during inception of OLPC (2010) through 2012	2010–2012. HTE served as headmaster at Tekin school during the inception of the OLPC program (2010); he resigned his headmaster position in late, 2012, eventually leaving the Oksapmin area
HAT	Headmaster at Tomianap School (until 2012), OLPC coordinator in Oksapmin (appointed by DOL), Headmaster at Tekin School after leaving Tomianap	2010–2014. In 2010, HAT served as headmaster at Tomianap School and was appointed by DOL as coordinator for OLPC in Oksapmin (2010); in 2012, HAT took up the position of headmaster at Tekin school serving in that position through 2014
REP	Representative from PNGSDP, the funder of the OLPC program	2011. REP flew to Oksapmin in 2011 for a 1-day visit to communicate to teachers/headmasters OLPC's vision that children be empowered with the XO personal computers.
HIX	Headmaster at Tomianap (after SN's transfer in 2012)	2012–2014. HIX was appointed as headmaster at Tomianap School after SN was transferred to headmaster at Tekin School; he was previously a teacher at Tekin school

trained. Some weeks after training was completed 385 XOs and peripherals arrived in Tekin, and some time after their arrival, technicians arrived to install servers at the three Baptist Union schools.

Management from the Inside: Local Efforts in Oksapmin to Accommodate Challenges. The arrival of the 385 XOs and peripherals into the community brought with them challenges. An immediate challenge was that the software on 385 XOs needed to be upgraded, a daunting task. HAT mobilized high school students to support the task, and VEM trained them in the procedure. The result was a resolution, though a partial one—some of the XOs failed to function, leading to somewhat fewer functional XOs than the number allocated by PNGSDP.

Another and more enduring challenge was to provide teachers with support to understand not only the basics but also ways to support students in the generative use of the XOs. For the hardware, this included how to open the XOs and to turn them on, understanding the functions of the varied ports, and knowledge of how to connect and operate the solar panels. For the software, it included how to navigate through the software—like the varied windows to locate particular applications and how the applications operated through their varied windows and commands.

These elementary hardware and software tasks were daunting for teachers for whom computers were alien machines. To provide support, VEM convened weekly Friday afternoon workshops in Tekin for teachers at the three Baptist Union schools. HAT assisted at these. The result was an extended training period. VEM reported (personal communication) that teachers developed some, but limited, capacity in their use – a level to be expected in a world in which such technology was foreign.

Had VEM not chosen to be in the Oksapmin community in the period that he was, and had HAT not been headmaster of a Baptist Union school during the same period, we expect that the program’s trajectory likely would have come to an early end. Indeed, VEM’s background in computational technologies was important for local support in XO



FIGURE 3. A photograph of the 2010 workshop in Banz, with VEM on the right.

use; HAT's enthusiasm and deep interest in computational technologies in his leadership role was important to encourage interest and commitment by teachers. The presence of VEM and HAT and their collaborative work enabled the development of a working knowledge of elementary classroom functions for the XOs by Oksapmin teachers. That stated, as VEM pointed out in an interview with us, by the end of his workshops with teachers, teachers' working knowledge of the XOs, XO activities (educational software), and management of servers was still limited. It was this teacher capacity with the XOs as well as organizational set up at schools that framed what occurred in classrooms over the next several years.

Threat #2: Religious Zeal that Targeted XOs

Several months after the XOs arrived in September 2010 and were distributed to the three Baptist Union schools, the XOs became a target of religious concerns by some, a zeal that energized church/community meetings. As a result, some parents were choosing not to send their children to school, a decision that, if spread rapidly, could have jeopardized the continuation of the program.

Background. In some respects, people's fearful reaction to the XOs on religious grounds should not have been a surprise. There is a strong and widespread Christian religiosity that exists alongside and/or fused with indigenous cosmology (for related systems of beliefs in other Mountain Ok groups [of which Oksapmin is one] see Barth 1987; Brutti 2000; Macdonald 2013; Whitehead 2000). The history of Christianity in the Oksapmin region dates back to the early 1960s, when the Australian Baptist Mission Station was built in Tekin. The Australian missionaries served at the mission through the early 1990s, and upon their departure, responsibilities for the mission shifted to pastors from the local community. Additional evangelical groups also penetrated the area after the Baptists entered; the new groups also succeeded in conversions. In 2014, there were a total of seven Christian denominations with varying numbers of parishioners: Baptist, Seventh Day Adventists (SDA), Papua New Guinea Bible Church (PNGBC, formerly Evangelical Bible Mission or EBM), Revival, Evangelical Church of Papua (ECP), Foursquare, and Flame Ministry (Macdonald 2013). Over the course of the short history of Christianity, there been numerous events evidencing religious zeal (e.g., people repenting for witchcraft [for example, see Boram 1976]).

Management of the Threat. There may have been many local conversations in which people expressed fears of the XOs – fears linked to talk by pastors and others who broadcasted concerns. But we were not privy to these. The information that we do have is confirmation that these fears were real in the community and that they eventually were quelled, at least to a degree that they did not interfere with the further development of the program. We also know that HAT, the OLPC coordinator (and headmaster at Tomianap Primary School), learned of the community fears and took action. He engaged in a campaign to quell the concerns, speaking with pastors, parents, and perhaps students. He reported that his focal argument was that computers were important for children's futures; he emphasized that computers were used in the world outside of Oksapmin and would help Oksapmin children to succeed. He reported that he also tried to dispel the worries by arguing that they were not warranted on religious grounds.

According to HAT, the religious zeal about the evil of the computers could well have led to a stoppage of the program. But it did not. One clear reason was the active role

played by certain members of the community. HAT was one individual that we know of who played such a role.

Threat #3: OLPC's Empowerment Vision in a Cash Poor Community

In 2011, a representative from PNGSDP, REP, made a 1-hour stop on a chartered small plane in Oksapmin to celebrate the distribution of XOs to the schools. During his visit, he made a recommendation that would have downstream consequences for the OLPC program. The recommendation was that the XOs be owned by children, to be taken home so that they would always be available to them. The perceived threat was that, if the representative's recommendation were heeded, it might result in the disappearance of many XOs and a halt to the program.

Background. One Laptop Per Child supports a vision of individual empowerment that has its roots in the early history of personal computing and education (Ananny and Winters 2007; Papert 1980). The educational pioneers in personal computing championed the idea that computational media should be designed in such a way that it was transparent to naïve users but at the same time could be used generatively to explore and build ideas (e.g., Bender et al. 2012; diSessa 1985). In the case of OLPC, the founders' commitment to personal empowerment and a paradigm shift in education was manifest in the belief that digital media should be densely distributed in communities, such that it becomes used as a part of daily activity, not simply linked to one province of life, like the school.

OLPC's vision of student empowerment was at center stage when REP, a representative of PNGSDP and viewed by some as a "visiting dignitary," flew into the community for a one-hour visit shortly after the laptops arrived. During this visit, REP gave a speech at a gathering of Oksapmin headmaster/teacher participants—a speech that would prove highly consequential for the development of the OLPC program in Oksapmin. In his speech, he reportedly explained OLPC's vision, declaring that all XOs and associated peripherals should belong to children and that they be free to take the computers home with them.

In the minds of some key community members, the representative's speech created a significant threat to the success of the program: if the laptops were distributed to students, many of them may not be returned to the schools. This concern is understandable given the cash poor local economy, in which commercial goods were increasingly sold for cash. Computers in the hands of children, the least powerful members of the community, might well become the property of extended families rather than "owned" by the children. Ownership has a different meaning in the Oksapmin world, where sharing and indebtedness through sharing is traditionally a central value (see, for example, Boram 1980; Guilford 1994).

Management of the Threat. This perceived threat was particularly acute in the mind of HAT, Tomianap's headmaster. He believed that if distributed, a great many laptops would disappear. His attempt to manage this threat took the form of simply retaining the laptops at the school. In an attempt to balance his concern with OLPC's vision, he allowed children to write their names on a computer and enter their name in the Sugar software, indicating that the laptop belonged to them.

Unlike the headmaster of Tomianap, the headmasters of Mitiganap and Tekin heeded the representative's directive, allowing students to take a laptop home (or, at the very least, the message was mixed and many students took them home). HAT's concerns

turned out to be well-founded. At Mitiganap and Tekin, over time, fewer and fewer computers returned with students. Reported uses of the computers in the community were varied. Some reports indicated that they were used as currency in trade with outsiders. Others suggested that adults and older peers in the community appropriated them. Solar panels used to charge the computers also disappeared into the community. With the rise in cell phone use after 2011 and no centralized source of electricity, some solar panels were adapted for use to charge cell phones. As a result of these losses of XOs and solar panels at Tekin and Mitiganap, there was insufficient hardware at the schools to support a high-density use of the technology in classrooms.

The directive of the PNGSDP representative, and the dutiful uptake by headmasters at Mitiganap and Tekin schools, led to a marked diminution in capacity of the OLPC program at these schools. However, it is important to note that this outcome was not inevitable, evidenced by the fact that sufficient hardware remained at Tomianap due to the headmaster's prescient decision. The disappearance of laptops and solar panels at two schools was a historically contingent development, occasioned in part by the representative's speech and the two headmasters' uptake of his message. As a thought experiment, one might imagine a different outcome—for example, if the representative had not made his short visit or if Tomianap's headmaster had convinced the other two headmasters to follow his lead in retaining the laptops at the schools.

Threat #4: Reassignment of Headmasters – Mismatch between XO Availability and Headmaster Fluency

The OLPC program seemed to be on a successful trajectory at one school: Tomianap. This school had the most knowledgeable and motivated headmaster, HAT, and the most hardware (XOs, solar panels). HAT reported that students and teachers were engaged with the laptops and that the teachers were in the process of developing lessons that took advantage of the laptops' capabilities. Threatening this local success, at the end of 2012, HAT was transferred to Tekin Primary School, where the headmaster had resigned and few XOs remained. HAT's replacement at Tomianap had comparatively little knowledge and motivation to actively support the OLPC program.

Background. Tekin, established in 1967, was the first school established in the Oksapmin area. The central government had a role in administering the school, but because of the remoteness of the Oksapmin area, the government engaged in a partnership with the Baptist Union. Soon, the Baptist Union also began administering nearby Tomianap and Mitiganap, the other two schools that would eventually participate in the OLPC program (although other local schools continued to be administered by the government, including Bak, Divanap, Oksapmin, and Tekap). To this day, Tekin remains the largest and most prominent school in the area and, as of 2005, supports the only secondary school in the region.

In late 2012, while the OLPC program was underway, HTE, the headmaster of Tekin, resigned. His resignation led to various re-assignments and appointments that had varied unintended consequences for the OLPC program. To address the vacancy at Tekin Primary School, the district's office shifted HAT, the OLPC coordinator and headmaster at Tomianap, to the vacant headmaster position at Tekin, an appointment that was taken as a promotion because Tekin was regarded as a more prominent school.

The resignation of HTE at Tekin was consequential in two primary respects. First, and most obviously, it transferred the headmaster most knowledgeable in the OLPC technology—HAT—to a school in which a significant percentage of the laptops and solar panels

had disappeared, Tekin. Second, it resulted in the appointment of a new headmaster at Tomianap, HIX, who was considerably less knowledgeable but had access to the abundant equipment that remained at the school. In our interview with HIX, we learned that he had little knowledge of how to operate the XOs, the Sugar software, or productive ways of making use of the XOs in instructional practices. On our visit in 2014, most of the XOs were left in storage at the school, unused.

Management of the Threat. In 2014, we interviewed HAT in Tekin, where he was reassigned as headmaster. He lamented that the XOs were in short supply, and he had been trying to retrieve the missing XOs from the community—with very limited success. Most of the originally provided XOs had disappeared, leaving less than a critical mass for the conduct of classroom-intensive work with them. At the same time, with the now limited supply, he engaged teachers with the use of the XOs to create homework assignments and other school-related materials. Students, however, had very limited access. HAT continued to emphasize the educational value of the XOs by dedicating a room to displaying artwork that students had created using XO software in prior years.

Threat #5: The Nationalization of PNGSDP Funds

The funding of the OLPC program in Oksapmin came from the PNGSDP, a not-for-profit company based in Singapore. PNGSDP was constituted to promote the sustainable development and welfare of people in PNG through social, environmental, and sustainable development programs and projects (Memorandum of Association of PNGSDP); to support its development mission, PNGSDP has three areas of responsibility: the conduct of a development program, the management of a long-term fund, and the oversight of Ok Tedi as the majority shareholder in Ok Tedi Mining (Callan 2012). In late 2013, the Oksapmin OLPC funding was cut off. The termination of support meant that there was no possibility for replenishment of computers, servers, and other aspects of the infrastructural supports, including software upgrades and additional teacher training. The occurrence was a profound threat to the sustainability of the OLPC programs in the three Oksapmin schools.

Background. PNGSDP was constituted in 2002 through the bequeathal of a majority share in the Ok Tedi gold/copper mine. The bequeathal came from BHP Billiton (a large Australian based multinational). Stephen Howes provides a succinct summary of the problematic issues involved in the negotiations that led to the establishment of the PNGSDP (Howes 2013) and ultimately the funding of OLPC in the Oksapmin area:

Essentially, BHP wanted to shut down the mine, which had caused great environmental damage and become a reputational risk to the company. The PNG government, however, wanted the mine to continue because it needed the tax revenue. BHP agreed to give away its ownership of the mine in return for a guarantee that it would not be sued for environmental damage. BHP did not want to gift its shares in Ok Tedi to the PNG Gov't because of well-established concerns about corruption and limited capacity within the PNG public sector. The compromise reached was an agreement that PNG would give its shares to a new trust fund, SDP, which would be registered in Singapore as a public company to be run by a board of directors, some nominated by BHP, the others nominated by a variety of PNG institutions. SDP was established in 2002. After a third shareholder exited, SDP was left with 63% of Ok Tedi's shares. The remaining 37% were held by the Government.

The abrupt nationalization of the PNGSDP and the Ok Tedi left OLPC in Oksapmin and related regions without development support. The event has led to both national and local efforts to sustain the OLPC program.

At the national level, PNGSDP took Prime Minister O'Neill and the Parliament to court (USDS 2014, June). Many viewed Prime Minister O'Neill's expropriation of \$1.4 billion as illegal—giving the government ownership of the country's largest company, Ok Tedi Mining Limited, and control over the country's second largest development organization, the PNG Sustainable Development Program (Callan 2012, July 10; Earl 2014, September 2; Earl 2014, August 28). Stephen Howes argues that the takeover of PNGSDP's assets "is quite possibly a temporary one, and it is an outcome which represents poor public policy and a setback to development in PNG" (Howes 2013, September 24). While Prime Minister O'Neill claimed that the courts are viewing the takeover in a favorable light, former PNG Prime Minister Mekere Morauta notes a recent view expressed by a judge in Singapore that "she thought PNG's claims of wasteful spending by the fund were 'unfounded' and had as a result dismissed PNG's request for a receiver to be appointed."

Local Efforts to Manage the Threat. There were local efforts to manage the threat of funding termination. For example, in Oksapmin, HAT in particular was active in trying to sustain and develop the XOs. He has been in communication with the former OLPC consultant through electronic communications; he had been active in his efforts to recover missing XOs; and he was actively involved in maintaining the servers at his school and using them to support teachers. However, these efforts were limited in their impact on the continued access to OLPC technology. In the two other schools, the OLPC project was functionally dormant by the time we arrived in Oksapmin. At Mitiganap, the headmaster displayed very limited working knowledge of how to operate an XO with few computers available, and at Tomianap, the XOs are stored for safe keeping, with working knowledge presumably dissipating among teachers.

Discussion

Educational interventions that introduce digital technologies to remote communities have met with limited success. The difficulties are often attributed to insufficient attention to cultural and material context. Though we regard context as critical to understanding the fate of an intervention, we regard as problematic the way context is typically treated. By default, context is objectified, conceived of a surround of individuals (Figure 4a) into which an intervention is inserted (Figure 4b). From such a perspective, an intervention succeeds or fails due to whether it is adequately aligned with context in which the intervention is inserted. By default, in this objectification, there is little analytic attention to the interpretive and productive activities of the varied stakeholders who participate in an intervention.

We find the objectified treatment of context problematic for both pragmatic and conceptual reasons. From a pragmatic perspective, the objectified treatment offers limited insight into the way an intervention could be better supported as it unfolds in a community. Specifically, it skirts an analysis of intervention-related vulnerabilities that could be managed and sources of local resilience that could be bolstered. In our process approach, vulnerabilities and resilience come out in particularly clear relief as threats to the continuation of an intervention emerge and become resolved. For example, in the Oksapmin case, we noted vulnerabilities emerged with religious concerns that laptops carried evil

into the community (Threat #2) or the lack of adequate preparation of teachers to use the XOs in schools (Threat #1). In the first case, we noted a source of resilience in the community as a headmaster spearheaded an effort to address the religious zeal; in the second case, we documented the presence of a volunteer in the community who voluntarily ran weekly workshops to support teacher knowledge of the XOs. We expect that findings like these could inform efforts to mitigate unintended consequences of initiatives and/or ways in which they might be addressed in communities.

From a conceptual perspective, the objectified treatment is problematic because it mischaracterizes the nature of context in three ways. Below we offer a corrective to each, noting how an objectified treatment of context would fail to capture key developments in the complex history of the Oksapmin OLPC program.

Context Is Inseparable from the Activities of Individuals

In the approach that objectifies context, we noted that individuals and cultural context are conceptualized as distinct and analyzed separately (Figure 4). Cultural and material context is treated, often by default, as if it were a surround of individuals, with elements of the surround affecting individuals' learning and development. From such a perspective, the intervention becomes a special aspect of context that may affect individual development. In a sense, the intervention becomes an independent variable, and its effects upon individuals become dependent variables.

What we found in the OLPC intervention shows the problems with an objectified treatment of individual–context relations. The properties of the intervention could not be adequately understood without reference to the intrinsic role of individuals' in interpreting, sustaining, and altering the intervention. In this sense, the intervention and individuals' activities became inseparable. We schematize the intrinsic relation between the intervention and individual activity in Figure 5, which depicts multiple individuals in the Oksapmin world interacting through time in intervention-related activities.

To illustrate this intrinsic relation between individual activity and context, we first consider the fact that individuals may interpret ostensibly the same cultural and material context in ways that may vary dramatically. Consider the perceived threat to the intervention generated by religious fears of some pastors and people in the community. For these people, the introduction of computational media (XOs, solar panels) became harbingers of doom and the introduction of evil to the Oksapmin world. For others, solar panels detached from the XOs became a source of electricity, objects that could be repurposed to charge cell phones. For still others like the headmaster at Tomianap (HAT), the

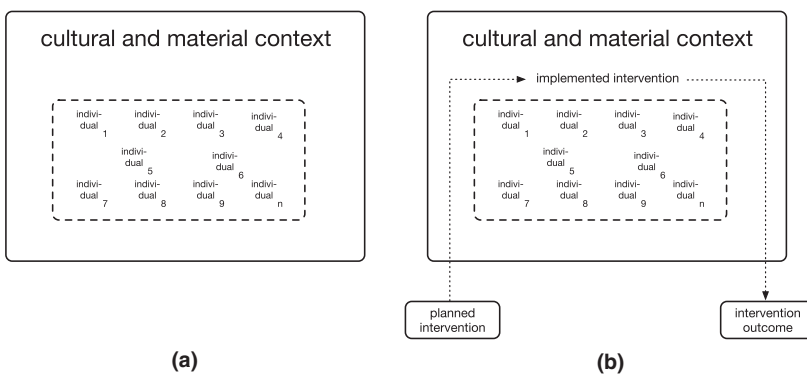


FIGURE 4. An objectified treatment of cultural context as a surround (a) into which an intervention is inserted (b).

same devices were an opportunity to advance in the educational system and the world beyond Oksapmin, and were sources of potential good. Such divergence in the way the devices were construed corroborates the idea that context cannot be understood apart from individuals' interpretations. Indeed, for these individuals, nominally the same context was experienced in quite different ways.

Context did not only reside in differential interpretations of individuals. Context itself was sustained and altered in the diverse activities of individuals. When a pastor preached on the evils of the XO's, he was generating an intervention-related context for members of his church to interpret. When individuals created means to repurpose solar panels to charge cell phones, they were generating a process that spread in the Oksapmin community, creating intervention-related contexts that became sustained in the Oksapmin world and had downstream implications for the disappearance of OLPC materials. When the headmaster engages in a campaign to halt the religious message from spreading, he brings forward the OLPC program in talk with others and also alters it in his efforts to engage others with the idea that the computers are not inherently evil and a potential benefit to Oksapmin children.

The Evolution of Context Is Historically Contingent

Explanations for the limited success of an intervention often treat the disappointing outcome, at least in retrospect, as a predictable result of a lack of fit between the intervention and the context in which it is "inserted." Such an explanatory account is ahistorical, failing to capture the role of contingency. In the Oksapmin case, for example, we found that the trajectory of the intervention could only be understood in relation to a host of perceived threats and individuals' efforts to either provoke or manage them. Had the threats and their management been different, we expect that the trajectory of the intervention would have been altered.

Imagine, for example, that HAT, the headmaster of Tomianap Primary School, did not initiate a campaign to quell the idea that the XO's were sources of evil (Threat #2) and that the idea spread through the Oksapmin world. Similarly, imagine that the headmaster at Tomianap had not disregarded the OLPC representative's decree to send the laptops home with children (Threat #3). In both cases, the result would have been an abrupt halt to the program.

Just as the OLPC program could have failed abruptly if threats had not been managed, the program could have met with greater success if the threats had been managed even more successfully or had simply not arisen. If all headmasters, for example, had rejected the OLPC representative's decree (Threat #3) (or if the representative had not visited), it

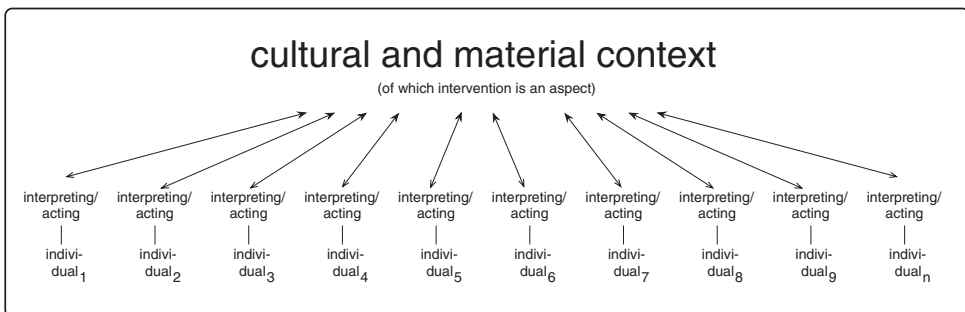


FIGURE 5. Individuals interpret contexts and their actions sustain and alter contexts.

is possible that the XOs would have been actively used in classrooms upon our arrival in June 2014. Further, even after the disappearance of the XOs, if the nationalization of the PNGSDP had not occurred (Threat #5), there would have been the possibility of a replenishing of the XOs in classrooms and greater support for teachers and students productive use of the computers.

Such thought experiments problematize the notion that the fate of an intervention can be predicted simply by an analysis of "fit" between the intervention and the context in which it is implemented. Indeed, an analysis of fit between the Christian beliefs and the Oksapmin world before Western contact might lead one to expect no uptake of Christianity by Oksapmin people. Such an expectation would be confirmed if one only considered the fact that missionaries achieved no converts after several years in residence. However, during the fourth year, a young Oksapmin man decided to convert, and once that occurred, over the next week, many more conversions occurred (Macdonald 2013). Subsequently, missionaries supported small cadres of Oksapmin male converts to return to their own communities to talk with members of their clans about the Christian faith. Macdonald (2013) provides compelling argumentation that it was the missionaries' decision to mobilize Oksapmin cadres to carry out the evangelical mission that gave rise to massive conversions and spawned a brand of Christianity that was distinctively Oksapmin. Further, Macdonald speculates that had the missionaries taken a different approach in their early evangelical efforts, the outcome would likely have been very different.

The Evolution of Context Involves Multiple Trajectories

In the objectified treatment of context, the outcome of an intervention is often taken as the result of a single trajectory. But the idea of a single trajectory fails to account for the complexity inherent in the varied interpretive activities of individuals at different locations – individuals who have different knowledge, perspectives, and motives. This complexity has the potential to give rise to multiple trajectories as an intervention evolves. The potential for multiple and distinct trajectories may be greatest when an intervention is implemented at multiple sites with different leadership and networks of actors. This increases the likelihood that an emergent threat will be handled differently at different sites, resulting in a differentiation of trajectories. This possibility is depicted in Figure 6.

The Oksapmin case is a clear illustration of the possibility for multiple trajectories. Consider the different trajectories that emerged at the three school sites in relation to emerging threats. HAT's decision to retain the laptops at Tomianap and the other headmaster's decisions to release them to students set the stage for different trajectories (Threat #3). At Tomianap, the productive use of the laptops continued to evolve with the support of the headmaster's leadership and motivation. But lack of laptops at the other sites limited the development of the program. The multiple trajectories continued to evolve with the reassignment of the headmasters (Threat #4). The reassignment led to the state that we encountered upon our visit in 2014. At one school, we found a knowledgeable and motivated headmaster with little available technology for productive use in classrooms. At another school, we found a headmaster with little technical knowledge and motivation, but who had access to a relatively large number of XOs. Finally, at a third school, we learned that there were both few available XOs and a headmaster with limited knowledge.

Concluding Remark

We end with a cautionary note. Any intervention carries with it assumptions about value. It may be assumed that an intervention will be helpful to a community in various possible ways—for example, in moving from what not long ago was a Stone Age to a digital age, in reducing the cost of educational materials, in empowering children, and in improving teaching and deepening learning. But there are generally unintended consequences with any program that makes efforts to change a community towards what external sources regard as better. We have seen some of these in Oksapmin. To name a few: only three of the seven primary schools receive the laptops, and that sparked local resentment among the schools left out, resentment possibly compounded by the fact that schools affiliated with only one Christian denomination gained participation in the OLPC program; the introduction of value technology in a cash poor world may have led some children to be victims, targets for theft of their laptops; finally, given lack of sufficient knowledge for use of the XO among some teachers, instructional activity that made use of the XO may have been at the expense of other instructional activities that would have been of greater benefit to students. Understanding the ways in which

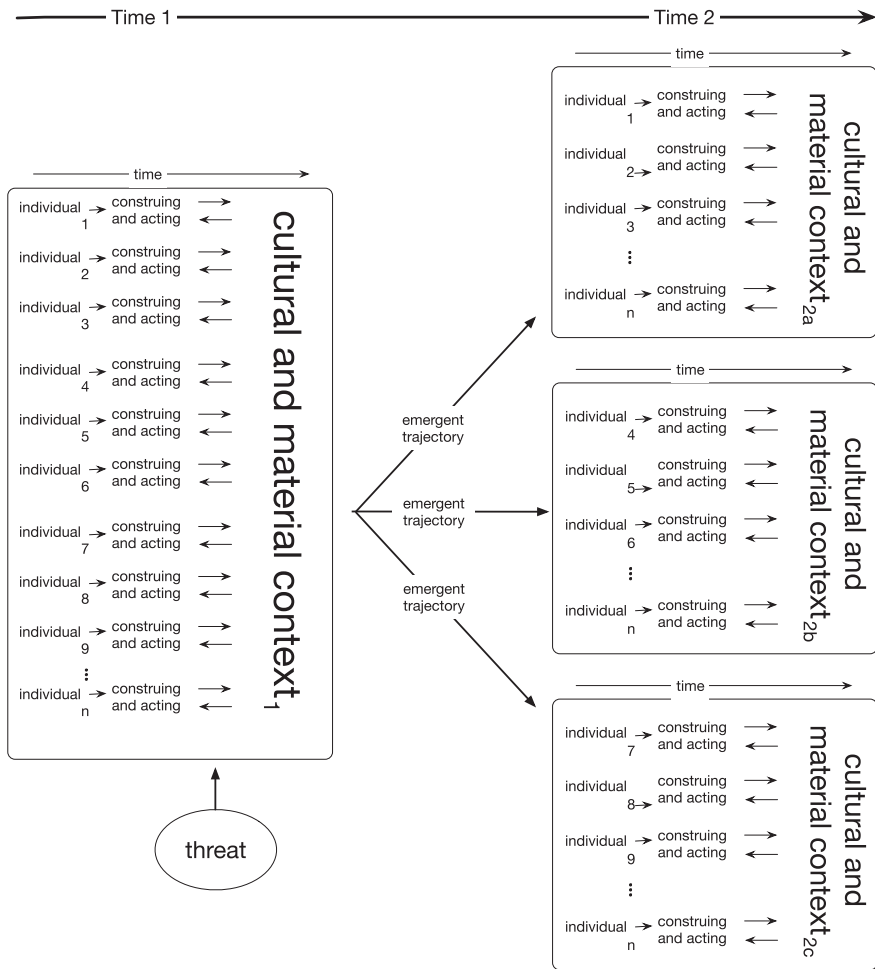


FIGURE 6. Differing local ecologies of an intervention (context-individual relations) may emerge as conditions differentially shift at different community sites.

the intervention benefited (or failed to benefit) the Oksapmin people requires an understanding of context as inherently dynamic, historically contingent, and inseparable from the activities of individuals. Without this, we are left with an impoverished account of an intervention, one in which its emergence, reproduction and alterations in people's local activities remains largely invisible.

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Notes

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