MAKING THE GRADE

A Study of Educational Technology in the Thomas Food Project

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Contents

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United Methodist Communications provides communication resources and services to local churches and annual conferences. United Methodist Communications also has a consultative relationship for communication and public relations with all general agencies of the global Church and with any structure at the jurisdictional, Episcopal area, annual conference, district or local church level.

About ICT4D

United Methodist Communications' Information and Communications Technology for Development ministry – otherwise known as ICT4D – is being used to transform communications across The United Methodist Church, and within communities in the developing world that have been most cut off from technological advances. United Methodist Communications provides technology, training and best practices to help your program become successful and sustainable.

Executive Summary

Despite the costs of designing and implementing high-quality technology solutions, technology-enhanced learning has delivered superior learning benefits and outperformed other interventions, such as smaller classes or teacher performance incentives alone, when introduced appropriately in developing countries. However, technology-enhanced learning is not trivial to implement effectively and takes extensive infrastructure building and educator professional development. The limited infrastructure and professional development opportunities in many countries add to the requirements for implementation.

The Thomas Food Project started in 2011 in Haiti, the most economically depressed country in the Western Hemisphere, in the aftermath of the 2010 Haitian earthquake. The project began as a hot lunch program for schoolchildren in the Thomas region. Since then, newer programs, such as computer-based education, have been launched. As the project expanded, its leadership began to consider ideas for participating schools to cover the long-term costs of the lunch program.

In this paper, we describe the early progress that the project has made, with an emphasis on computer-enhanced learning, which aims to provide educational and economic opportunities to Haitian students from high-poverty backgrounds.

- Our findings are based on seven weeks of field research, from May 17 to July 4, 2014, during which the first author visited two participating schools where he interviewed two principals, 12 teachers, six parents, 10 students, and 15 additional community members.
- During the same time period, he observed 137 students from kindergarten to sixth grade in a total of 11 computer sessions.
- In these sessions, students shared the computers to engage with open-source educational software that targets computer literacy, French, mathematics, and science.

Students, parents, and other adults volunteered their perspectives that computing skills are useful, and several of them added that these skills would help them to find jobs in the future. An important issue is that the solar power infrastructure at participating schools suffers from technological limitations, which make it impossible for the computing facilities to be fully utilized in order to realize the potential of technology-enhanced learning. The project's leadership is aware of this barrier and is exploring solutions to improve the effectiveness of the project's computer-based education programs.

Finally, this discussion paper addresses the Thomas Food Project as a context to provide recommendations on the design and evaluation of technology-supported learning programs. The goal is to send volunteers to implement similar programs in low-resource regions around the world with a framework for improving the effectiveness of their programs.

Introduction

The costs of designing and implementing high-quality educational technology solutions are high, yet technology-enhanced learning delivers superior learning benefits and outperforms other interventions, such as smaller classes or teacher performance incentives alone. Technology-enhanced learning is not trivial to implement effectively and takes extensive infrastructure building and teacher professional development.

The Thomas Food Project began in 2011, in the aftermath of the 2010 Haitian earthquake, as the brainchild of Warren McGuffin, a retired entrepreneur and member of the United Methodist Volunteers in Mission based in California. The project began as a hot lunch program for students in the Thomas Methodist School in the Thomas region of Haiti. Initially, the project was focused on feeding the students and providing the community with clean drinking water. Mr. McGuffin began to envision ways to make the lunch program self-sustainable through microenterprises. The goal was to help participating schools generate income to cover the costs of lunch programs.

One microenterprise idea involved making computers and ancillary services, such as computer literacy programs, accessible to communities for a fee while keeping these computing facilities free of charge to regular school students. The project's leadership sought out technology companies that could implement computer-based programs in Haiti and learned about a firm named Inveneo. Inveneo's website indicates that it is a leader in "bring[ing] together hardware, software and power to create systems that are affordable and sustainable in some of the most challenging environments in the developing world."

The project collaborated with Inveneo and local partners to install solar panels and a computer center in the Thomas Methodist School in January 2013. The project then trained all teachers in the school on basic computer literacy.

Building on this new computing infrastructure at the Thomas Methodist School, the project charted a "sustainable path out of poverty" based on an integration of humanitarian aid and church missions and gifts. At the time of this writing, the programs not only included school lunches, water purification, and computer-based education but also encompassed clothing donations, pen pals and solar lighting.

During the project team's visit, the idea of a portable power source was born that could supply laptops with electricity to increase the scale of computing access. Based on this, the project team designed a portable cart on which a solar panel was mounted. The project team referred to this cart as the Mobile Educational Center. The first two carts were deployed in December 2013, with plans to build and distribute more carts to other schools.

A Mobile Educational Center cart that the Thomas Food Project built and distributed to the School of Hope in December of 2013. The cart allows a school to power laptops and other battery-powered devices without building a room to house a permanent computer center.

This discussion paper resulted from a partnership between the United Methodist Communications' (UMCom's) ICT4D team, the Thomas Food Project's leadership team, Emory University, and American Institutes for Research (AIR). UMCom supported this paper, which documents the use of technology to improve education and for evaluation of ICT4D programs.

The field research assessed the progress of the computer-enhanced learning programs in two Haitian schools supported by the Thomas Food Project. Unlike traditional indicator-driven, data-based monitoring and evaluation systems that rely purely on quantitative research, a qualitative approach enabled project implementers to diagnose areas in the programs for continuous improvement as a prelude to a more formal evaluation.

Data Collection

The first author spent seven weeks in Haiti (May 17–July 4, 2014) to carry out field research. He observed the computer-aided learning that Thomas Food Project staff supported for regular students at the Thomas Methodist School and a similar project-supported, computer-aided learning program for students at the School of Hope using its Mobile Educational Center.

The Thomas Methodist School and School of Hope are located in the villages of Thomas and Sous Rigole. Both schools were selected as research sites because they are the first two schools where the project team implemented computing facilities. Both communities were observed using the computing facilities and their members interviewed on their experiences so far with the project, with the overall goal of obtaining feedback for improving the programs.

Throughout the field research period, the first author stayed in the guesthouse at the Thomas Methodist School. This guesthouse was built to host United Methodist mission volunteers who visit Haiti to support the project. By living in the guesthouse, the first author positioned himself to establish better rapport with community leaders as well as to familiarize himself with the community. This step facilitated access to respondents (to interview) and daily events (to observe) at Thomas.

Despite infrastructural barriers relating to electricity and Internet connectivity, he was successful in writing email updates at least once every week to the project's leadership in California, UMCom's leadership in Tennessee, and to the second author, all of whom provided prompt feedback regarding data collection.

School Principals

The project's manager introduced the first author to the principals of the Thomas Methodist School and School of Hope when the former accompanied him to both schools. Both principals made themselves readily available to the first author whenever the latter had questions after observing the programs and interviewing their participants. The interviews covered the teachers' and students' experiences with the computers, reasons for how and when computers were used, general questions about the schools, and demographics of the local communities.

Community Members

To obtain a more well-rounded perspective, the first author sought out other community members in Thomas with whom he could speak. Interviews covered what respondents perceived to be useful about computers and their impressions about the project thus far.

Limitations

Given the population's enthusiasm for the World Cup in June 2014, data collection was affected in ways that had not been anticipated. Specifically, the spring semester for schools in Haiti ended earlier than originally scheduled. Consequently, the first author was only able to visit Hope for a maximum of six days (down from the 10 days that were originally planned) and Thomas for eight days (down from 10 days).

There were challenges in collecting details about or from respondents through interviews. Our interpreter cautioned that it was awkward to ask teachers about their educational attainment. A plausible explanation is that in Haiti only 15 percent of teachers at the primary level have basic teacher qualifications (including bachelor's degrees), while nearly 25 percent have never attended secondary school. As such, the first author first tried to find out more about the teachers' educational backgrounds by asking the principals instead. However, the principals seemed to avoid giving a direct answer and responded instead with the number of years' experience each teacher had.

Second, teachers were unable to respond readily when asked about their teaching philosophies and/or rationale for using computers in their classrooms in the ways that the first author had observed. The training teachers received was expected to influence the ways in which they used the technology, as well as how they selected which software and digital learning content their students should use. When and how long this training took place, what went into this training, and how this training was conducted were expected to contribute to a teacher's effectiveness in using technology to enhance learning. As such, the authors wanted to review the training materials (e.g., syllabi, handouts, slides, video recordings) and/or observe selected sessions to identify specific areas where more training could be provided or improved.

What the authors did learn is that Inveneo held a three-day training workshop for a school's principal and teachers when a computer lab or Mobile Educational Center cart was first installed. Afterward, local staff conducted follow-up training sessions. At the time of the first author's visit, three follow-up sessions had been conducted earlier that year. Local staff indicated a preference to hold one of these sessions every two months. We were told that the teachers were taught how to use computers, how to use the educational software that came pre-installed, and how to teach using the technology.

Finally, we had planned to experiment with information and communication technology tools for data collection. One of these tools is a screen capture software called Snagit, which captures what appears on a computer screen as video recordings for playback and review of what the user was doing on the computer. Such a tool would allow researchers to observe more computer sessions, especially those that the first author could not observe.

By reviewing these video recordings, the program would be able to identify more opportunities for improvement in the areas of computer literacy skill and the use of technology for teaching and learning. Unfortunately, due to technical issues that could not be resolved while the first author was in Haiti, we were not successful in installing Snagit on the computers at Hope and Thomas.

The Thomas and Sous Rigole Communities: Similarities and Differences

The Thomas Food Project works in partnership with schools in Haiti, including the Thomas Methodist School and the School of Hope. The Thomas Methodist School and the School of Hope are located in the villages of Thomas and Sous Rigole.

Although the Thomas Methodist School and the School of Hope are only 15 minutes' drive from each other, their surroundings are very different. There is always activity outside the Thomas Methodist School since the school is located along National Highway #1, which is a major highway that connects Port-au-Prince (Haiti's capital) to Cap-Haïtien (a large city on the northern coast of Haiti). By contrast, the School of Hope has a quiet atmosphere because it is surrounded by small homes and farms.

The communities in both Thomas and Sous Rigole are poor. The most common occupations are driver, farmer, salesman, and teacher (for men) and farmer, saleswoman, and teacher (for women). Average monthly income is approximately 1,000 HTG for a male farmer (US $22 at the exchange rate of 45 HTG to US$1) and 3,500 HTG for a teacher (US $77). Homes are typically gated two-room cement homes, with patio areas outside. There is typically only one single bed in each home, but occupants normally sleep on the floor either inside or outside.

Thomas Methodist School

The Thomas Methodist School was founded by the Thomas United Methodist Church in 2002. It is a primary school with five teachers and 192 students in Grades 1–6. The school and church share a two-story building, such that the school is housed on the entire ground floor while the church occupies the entire second floor.

Primary school students in Haiti are required to study five subjects: Creole, natural science, French, mathematics, and social science. The Thomas Methodist School teaches all five subjects. At the end of each academic year, students take the final examination for each subject. First through fifth graders in Thomas take their final exams at the Thomas Methodist School, while sixth graders travel to a larger public school in Arcahaie for their final exams.

During the 2013–14 academic year, the school had 192 registered students from Grades 1–6 (4 to 18 years old). Only 125 students attended classes regularly, due to financial difficulties. The school fees for a year of classes are 3,250 HTG (US$80). In addition to fees, uniforms cost 1,000 HTG (US$22) per student, while books cost between 1,250 HTG (US$28) for first graders to 3,000 HTG (US$67) for sixth graders. The national government provides a subsidy for students in Grades 1–3 at the Thomas Methodist School, which reduces the cost of attendance to 500 HTG (US$12.50).

In January 2013, the Thomas Food Project commissioned Inveneo to establish a computer center on the ground floor of the school. At the same time, two solar panels were installed outside the school building to power both the school and church and were, in fact, their only sources of electricity. These developments started when the project selected the school as the first site where it would expand its program offerings (i.e., beyond the school lunch program) to encompass digital literacy and 21st-century technology-enhanced learning.

In the process, 10 Asus Eee Box desktop computers were placed in the computer center. The computer center does not have Internet connectivity. However, the project is investigating options for providing each computer in the center with Internet access. The project is also exploring the feasibility of operating an Internet cafe using the center's computing facilities.

Before the center was established, two teachers reported that they previously used computers to perform basic tasks using Microsoft Word and the Internet. Specifically, they knew how to create simple documents that involved little to no formatting, check email, and use Facebook.

Once the center was established, Inveneo conducted training sessions to provide teachers with the skills needed to use the computers as educational tools. Since most students had never used computers, teachers were responsible for imparting basic computer skills to them. Laptops were also loaned to the principal and each of the five teachers. With the project supporting computing facilities and computer literacy at the school, computer literacy has been introduced as a sixth subject to all students. Consequently, students have to take an additional (and sixth) final exam on computing that the school devises and administers.

School of Hope (Ecole de L'espoir)

Ecole de L'espoir, which means "the School of Hope," is located on a hill in a sparsely populated area. The school has seven teachers and 133 students from kindergarten to fifth grade. Its principal believes formal education opens the door to opportunity and hope.

In December 2013, the Thomas Food Project selected the School of Hope as the next site to introduce its growing digital literacy program. Owing to the capital expenditure required to install infrastructure for a solar-powered computer center, the project looked for less expensive options for the School of Hope. This led to the experiment with a solar panel retrofitted onto a movable cart, which can recharge up to four laptops at a time. Given its mobility and non-reliance on fixed infrastructure, the cart was called the Mobile Educational Center.

To accompany the Mobile Educational Center, the project distributed 10 Intel MG series laptops to the school, pre-installed with the same software as the computers in the Thomas Methodist School.

Like the Thomas Methodist School, there is no Internet connectivity at the School of Hope. However, some teachers at the School of Hope possess portable modems and pay for data plans to access the Internet. They use the laptops in this way to check e-mail and access Facebook. Inspired by his teachers' Internet connectivity, the school's principal explained he has been considering having community members pay to use his school's laptops as a revenue stream since he is aware that some community members own similar modems and pay for data access.

The School of Hope has an additional source of electricity besides the Mobile Educational Center. A few months earlier, in October 2013, a team of United Methodist mission volunteers from the West Coast of the United States installed a solar-powered streetlight at the school. As the only streetlight that is within an hour's walk, it draws community members to the school after dark to socialize and study.

After the Mobile Educational Center was introduced, Inveneo conducted training sessions to familiarize every teacher at Hope with basic computer skills. After that, the project's manager later provided follow-up training. At the time of the first author's visit, the project's manager had conducted four training sessions at the school. Teachers have asked to be loaned laptops to familiarize themselves more with the technologies. Teachers in turn taught their students to use the computers.

Principal Findings

Students at both schools appear to have benefited to some degree from the Thomas Food Project, which supports free hot lunches, street lighting and computer-based education, among other programs.

Regarding the school lunch program, interviews with students, parents and other community members indicated that most parents did not have the resources to provide their school-going children with more than one meal every day. As such, three parents and four students expressed their gratitude that students were receiving free lunch on school days—a meal that they would not otherwise have.

Similarly, a cook at the Thomas Methodist School noted that the number of students at the school increased from 75 when the lunch program began in 2011 to about 125 as of May 2014. She believes it is the lunch program that is responsible for successfully attracting more children to attend classes at the school.

The School of Hope's principal told us that the streetlight, which the project installed on its campus is invaluable to the community. Since not many other places in the surrounding areas have electricity, the street light transformed the school into a location where students, youths, and other members of the community come to socialize and study after sunset. Community members sit in one of the classrooms and study under the radiance of the street light.

With regard to the computer center at the Thomas Methodist School and the Mobile Educational Center at the School of Hope, 25 respondents shared their impressions. For instance, a parent of a sixth grader at the Thomas Methodist School noted that her son was more excited about school after the computer center was established and that his computer skills would help him to find a "good job" after he graduates from high school. Her son added that he wanted to continue learning computer skills, which implies that he views computer literacy as an important skill. A mother at the School of Hope offered that Haiti would continue to fall behind other countries until its people gain computer skills. She was grateful that her daughter had the opportunity to acquire computer literacy in school.

Of the 25 respondents, 14 students, parents and other adults viewed the computing facilities favorably because they perceive computing skills to confer significant economic benefits, such as an advantage in securing jobs in fields such as banking, healthcare and journalism. One student at the School of Hope even felt inspired to become a teacher. Furthermore, 10 students and an adult in the community advocated having computers in school, found it enjoyable to computer skills, and self-reported that the computers improved learning.

The initial impact of the computing facilities at the School of Hope and Thomas Methodist School was even more profound since the majority of residents in Sous Rigole and Thomas had never used a computer. Respondents who had previously used computers included two teachers at the Thomas Methodist School, three high school students, a journalist and a banker.

Teachers at both the School of Hope and Thomas Methodist School appeared excited to acquire computer skills. Teachers at the School of Hope requested that the project loan them laptops for work-related purposes. In the meantime, they were using laptops in school to plan lessons, prepare test papers, and access email and Facebook.

Similarly, at the Thomas Methodist School, the principal observed that both students and teachers enjoyed using the computers. The principal noted that computers helped his students to learn French and mathematics better. In his opinion, teachers found it easier to prepare test papers using computers.

In view of the progress that the project has made in its initial stages and in interviews, it appears that more resources should be invested to increase the project's capacity at existing sites. For instance, seven students at both the School of Hope and Thomas Methodist School, as well as a cook in the project, indicated that their schools need more computers so that students have a more meaningful level of computer access.

How Often Were the Computers Used?

According to principals and teachers at both schools, the solar panels generated enough power to enable each computer to be used for up to two hours per day. This was consistent with the first author's time in Haiti, when skies were often overcast. There was a week when the computer center at the Thomas Methodist School lacked power for three consecutive days.

As such, it appeared that each student at the Thomas Methodist School received up to two hours of computer access per week, and that time was shared with one or two classmates. Although the solar panels at the Thomas Methodist School supplied up to two hours of electricity per day to power the computers in the center, there was usually surplus electricity for the center to be used after school hours. This was because the sessions that were scheduled for regular students often started late or ended early as a result of teachers needing to spend more time in the classroom to complete the regular planned lessons.

On the other hand, since the New Vision classes (another educational program) took place in the computing center on Monday and Thursday afternoons, it seemed that the New Vision program competed on those days with sessions that had been scheduled for regular students. In other words, if there was insufficient electricity on any day to support both the computerbased education session for regular students and New Vision classes, the New Vision classes received priority and regular students at the Thomas Methodist School (i.e., first or fourth graders) did not get to use the computers.

At the School of Hope, each student received less hands-on time with a computer than counterparts at the Thomas Methodist School. It became clear that the solar-powered battery in the School of Hope's Mobile Educational Center cart possessed a lower capacity than the battery powered by fixed solar panels at the Thomas Methodist School. Thus the School of Hope's battery was able to charge up to four laptops at once, in contrast to 10 computers that the Thomas Methodist School's battery was able to power at once. Hence, in spite of the School of Hope having 10 laptops, power constraints made it challenging for its 10 laptops to be used at once.

The principal indicated he has requested a second battery from the project so that his school's Mobile Educational Center cart would be fully utilized with a battery for its solar panel to recharge at any time. When a battery is fully charged, he could remove it from the cart and use this battery to recharge four laptops while simultaneously connecting a second battery to the cart's solar panel to charge the second battery.

Unlike the Thomas Methodist School, the School of Hope has no schedule to determine computer usage. Instead, the school tried to fully use its laptops by having multiple classes share the laptops. Assuming there were only two laptops that were fully charged, teachers assigned both laptops to a class for half an hour before assigning both laptops to another classroom. In each class, every laptop was passed from one student to another. If a student did not have a laptop but was seated close to a student who did, the former looked on as the latter was engaged in work.

The challenge with limited sunlight at both the School of Hope and Thomas Methodist School was exacerbated by other demands that their surrounding communities placed on the electricity generated by their solar panels. When the project manager visited the School of Hope, he found the Mobile Educational Center cart used to power personal devices, despite instructions that the cart is to be used exclusively for charging the laptops. Similarly, community members visited the Thomas Methodist School as frequently as four to five days every week to recharge their mobile phones after class. Finally, community members sometimes plugged a television set at the Thomas Methodist Church into the solar battery to watch sports and Christian programming.

In What Ways Were the Computers Used?

At the Thomas Methodist School's computer center, students shared its 10 computers in groups of twos and threes. There did not seem to be a specific method in place for assigning students to groups (e.g., differentiated instruction in which students are grouped by ability) such that each group was assigned a computer-mediated learning activity based on the abilities of students in that group.

Instead, when a class walked into the center, students seemed to head for a computer near their friends or to an unoccupied computer. In every group, students passed the mouse and keyboard around. In the few instances that a student would not give his or her group members a turn at the computer, the other students brought the situation to the attention of the teacher, who instructed the student to pass along the mouse and keyboard.

The first computer session at the Thomas Methodist School involved its 21 first graders and lasted 60 minutes. Most of the students appeared to know how to turn on the computers and to start the G-Compris software on their own. The teacher went around to help students who were taking too long to start G-Compris. Launched in 2000 as an ongoing open-source effort that targets children between 2 and 10 years old, G-Compris is a suite of educational software comprising over 130 learning activities focused on keyboard and mouse skills, reading literacy, numeracy, science, geography, etc. G-Compris is available for free and has been translated into over 50 languages. We believe that G-Compris was selected for use because students enjoy the software and teachers are familiar with it.

The first computer session in the School of Hope lasted 30 minutes and involved 15 third-graders. There was only one laptop in the classroom for the first 10 minutes, after which a second laptop was brought into the classroom. The students were excited when the second laptop arrived, since it meant that they had one more computer to share.

By the end of the session, it seemed that only a total of eight students had an opportunity to use a laptop. Each of these eight students used a laptop for approximately five minutes before being told to pass it to another student. In this session, students played the G-Compris game in which they counted the sum or difference of stars in constellations. Students also appeared to enjoy taking photographs of themselves using the built-in camera on the laptops. The teacher seemed to think we were observing this session in order to evaluate him. He therefore looked preoccupied with our presence and tried to make himself available as much as possible to answer our questions. As such, it was neither possible to observe how he normally facilitated the use of the laptops in class nor to closely observe how students used the technology.

In the second session, we observed 10 fifth graders playing the human anatomy game in G-Compris for 30 minutes. Only five students managed to use the computers directly during this time since there were only two laptops in the classroom. The students seemed comfortable with the technology and needed no help in operating the controls. Students who were seated near students with laptops watched the latter match the human body parts to their names. Unlike the first session at the School of Hope, the teacher spent more time in classroom management as opposed to engaging with visitors. For instance, he helped his students whenever they were unsure which word to match with a body part. Moreover, when a student tried to use the laptop's built-in camera to take photographs of himself, the teacher stopped him and instructed him to start the anatomy game again.

The third session lasted 20 minutes and involved 11 fourth-graders playing a typing game in G-Compris called "Simple Letters." In this game, a new letter appears on the screen every few seconds before it begins to fall vertically. The goal is to press the corresponding button on the keyboard before the letter reaches the bottom of the screen.

The students were sufficiently familiar with the keyboard to find and hit most of the buttons before the corresponding letter reached the bottom of the screen.

Students were able to find and start this game easily in G-Compris, possibly because this was not the first time they had played it. Since this class had only one laptop, students passed the laptop to one another every 2–3 minutes, allowing every student time to use the computer. The teacher did not actively facilitate the session besides instructing each student to pass the laptop around after completing levels in the game.

The fourth and last session that we observed in the School of Hope took place after school hours and lasted 20 minutes. Like the Thomas Methodist School, whenever battery power permitted, students at the School of Hope were allowed to use the school's laptops 2-3 days every week after classes for their homework and other academic purposes. A teacher was assigned to each session to supervise students' use of the technology and to provide technical assistance. In the session, four laptops were in use.

Since the teacher did not regulate who was allowed to use the laptops and when each student was allowed to use a computer, the laptops appeared to be in the hands of the older students (i.e., fourth- and fifth-graders). Throughout the 20-minute session, only one laptop was passed to another student. Students accessed G-Compris, a French-to-Creole dictionary software, and other software applications on the laptops. The G-Compris users appeared to be enjoying themselves but did not seem to have specific learning objectives that they were required to attain. In contrast, students who used the dictionary were looking up the meanings of words that were assigned in their homework. Students told us that they enjoyed using the laptops to play the educational games in G-Compris and to take pictures of themselves.

Building on our previous observations, we interviewed teachers in both schools to learn more about their computer usage and to probe more deeply into their beliefs and attitudes about how computers could be used to improve teaching and learning. Teachers in both schools confirmed that G-Compris is the e-learning software that they used most frequently with their students. Other educational software that they used, but much less frequently, include the French-to-Creole electronic dictionary, Microsoft's Learning Suite, and Microsoft Mathematics.

Students appeared to be taught the same computing skills across both schools. First and second graders focused on learning the basics of computing (e.g., how to turn the machines on and off, what are the various parts of a computer, and how to look for and start various software applications in Microsoft Windows), while third-, fourth-, and fifth-graders learned to use specific applications. Similarly, while second-graders learned to type sentences in Microsoft Word, students in higher grades learned to change the font, size, and color of sentences in Word. Although students played the same G-Compris games in all grades, students in more advanced grades played the more difficult levels (e.g., second-graders played levels in G-Compris games that targeted addition and subtraction, whereas fifth-graders played levels in the same games that involved multiplication and division).

Most importantly, the instructional staff did not fully articulate a compelling rationale for their use of technology that would convince policy makers or investors about the value of educational technology. For instance, a teacher said the French-to-Creole dictionary software is useful for students learning French but did not support her position with specifics. Similarly, three teachers claimed that computers are useful for displaying the abstract concepts that they teach in class and helping their students visualize these concepts but did not elaborate on why similar visualizations could not be presented using less expensive media such as print and the blackboard. Finally, two teachers observed that their students were more eager to learn on those days when they had a chance to use the computers but could not elaborate on how they took advantage of this interest to enhance student learning.

Recommendations

Based our findings, we outline some broad recommendations that are applicable to a wide audience of education, social sector, and public sector leaders who implement technology-enhanced learning programs in low-resource settings. In the hands of a master teacher, technology can be a powerful tool that enables the educator to amplify his or her teaching impact within and outside the classroom. This calls for a strong commitment to teacher professional development that equips the teacher to become increasingly effective in facilitating student learning, both with and without using technology. What then, should teacher professional development for technology-supported learning environments emphasize?

As research suggests, a skilled teacher is well versed in the subject that he teaches (i.e., content knowledge); the techniques of good teaching that are independent of any subject (i.e., pedagogical knowledge); and the preconceptions, misconceptions, and other learning challenges unique to the given subject (i.e., pedagogical content knowledge). To be effective in a technology-enhanced learning environment, a teacher needs to know how to use specific hardware and software packages (i.e., technological knowledge), how to facilitate learning in general using technology (i.e., technological pedagogical knowledge), and how to use technology to help students overcome learning challenges that are specific to a given subject area.

Building on these distinctions in areas of teacher knowledge, recommendations focus on two broad spheres; namely, gap analysis and program design. In particular, given that technology in education is often perceived as "a solution in search of a problem," program implementers can make a more compelling case for using technology after they have performed a gap analysis to diagnose the knowledge and skills that ought to be prioritized using technology. This is especially crucial in low-income settings where resources are scarce and need to be used optimally.

Gap Analysis

- Define and state the educational problem clearly. Assess learners in each grade level to identify the knowledge and skills where they need the most support vis-à-vis grade-appropriate curricula goals.

⏩ Properly document and organize all teacher professional development resources. Materials such as professional development syllabi, schedules and handouts provide visibility as to what teachers ought to know in terms of their content knowledge. Program implementers should not neglect the non-technology components, especially in underserved regions where many teachers need to continue growing in their knowledge.

⏩ Leverage suitable technology tools. Videotape all teacher training sessions to facilitate similar sessions for future cohorts of teachers, thereby allowing teacher training to be implemented at scale without suffering significant loss in fidelity. The recordings can also be used to understand how teacher training was carried out and thereby identify areas that received less attention and on which future training needs to focus. For students, screen recording software can be used to monitor computer use in places and times that are less accessible to monitoring and evaluation staff. Program implementers can review this trove of screen recordings to identify gaps in student knowledge of academic content areas and technology skills.

Program Design

⏩ Design computer-supported learning activities that have appropriately challenging educational goals. As soon as second-graders at the Thomas Methodist School have demonstrated their ability to correctly perform addition and subtraction involving answers as large as 15 (which is closer to what kindergarten students and first-graders should be capable of), they should be assigned to more challenging digital learning content and activities that "stretch" them. When using technology in heterogeneous classes, students can be grouped by ability so that more difficult activities and content can be assigned to advanced students.

⏩ Ensure that selected students have enough hands-on time with a computer. Cognitive science research has shown that mastery comes from having sufficient practice accompanied by relevant feedback. An important implication is that students require adequate hands-on time with a computer in order to acquire basic computer literacy and/or attain the learning goals behind the digital learning activities.

Assuming there are no resources to increase the computer-to-student ratio, use more energy-efficient computers, or provide more solar equipment, we recommend computer access be prioritized for selected students (e.g., students in higher grades) so that they have more hands-on time to develop their computer literacy skills further. In the case of the Thomas Methodist School, this may involve swapping the 11 a.m.–1 p.m. sessions for second-graders and fourth-graders such that it is the second-graders (instead of the fourth-graders) who miss their computer sessions on those days when there is insufficient electricity.

⏩ Design learning activities to engage computer users and non-users at the same time. In settings such as the School of Hope—where it is not possible to power enough computers for all students to share a computer at the same time—appropriate "blended learning" models that involve rotation could be explored. For instance, students could be divided into two groups. In the first group, having an equal number of students and computers allows for sharing to carry out technology-mediated learning. Students in the other group await their turns to use the computers. They could be assigned appropriate educational tasks in the meantime to keep them from off-task behaviors (e.g., chatting with their classmates).

Despite our observation that technological knowledge on the part of students and teachers is critical to the success of a technology-enhanced learning program, other components such as content knowledge, pedagogical knowledge, and pedagogical content knowledge should take precedence in the overall scheme of things. These elements comprise essential knowledge that teachers need to design compelling learning activities. Teachers also require support to develop the classroom management skills that they need to carry out these activities effectively in classrooms. While the above objectives cannot be achieved overnight in low-resource settings, putting the structures and culture in place for local educators to engage in meaningful conversations is the first step.

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