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Comparative Advantages of Offline Digital Technology for Remote Indigenous Classrooms in Guatemala (2019-2020)

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Abstract: Technology has been viewed as a means to improve the quality of education for children globally, particularly in remote and marginal communities. This study examines the comparative advantages of the use of appropriate technology (off-line servers with digital libraries connected to a classroom set of laptops) in ten intervention schools in Indigenous communities in Guatemala for one school year. The study was too short (due to pandemic restrictions) to demonstrate statistically significant differences for learning outcomes. However, using an instructional core model as a framework, qualitative findings supported four previously identified comparative advantages, and identified four additional ones relevant to remote Indigenous communities. The intervention validated the ability of technology to improve standardised instruction, differentiated instruction, opportunities for practice, and learner engagement. Newly identified advantages are: access to high-quality educational resources (substitution for print materials), teacher capacity-building, student technical skills and digital literacy, and sharing cultural knowledge.

Keywords: technology for global education; digital education in remote communities; educational technology, Indigenous communities.

Introduction

Despite the expectation in the past few decades that technology would be able to improve the quality of education for children and youth around the world, the results have not yet met expectations (Sancho-Gil et al., 2020). Building on recent efforts to identify the specific technology-based strategies that can improve student learning, this study explores the potential advantages of technology for schools in remote Indigenous communities.

The "Instructional Core" model provides a theoretical framework for this study (Cohen & Ball, 1999). In this model, student learning can be understood as the result of a **teacher** and **student** in the presence of **content,** like three points of a triangle. The three elements interact to facilitate student learning which is at the centre, or *core*. The *relationship* between these three elements, and not the qualities of any one element, determine the nature of instructional practice and the resulting student learning. There is on-going exploration of the balance between these elements (Anderson, 2003), however, it is clear that the three components are interdependent, and that a change in one, will affect the other components and the resulting student learning. Thus, improved learning can occur with:

1. An increase the teachers' instructional knowledge and skill (teacher capacity);
2. An improvement in the quality and appropriateness of the content students learn (quality content);
3. A change the role of the student in the instructional process (student engagement).

Using this model as a base, the Brookings Institution (Ganimian et al., 2020) identified four promising comparative advantages of technology at distinct intersections of the teacher-student-content triad (Figure 1):

1. **Scaling up standardised instruction** through distance education and pre-recorded lessons;
2. **Facilitating differentiated instruction** through live one-on-one tutoring and computer-adaptive learning;
3. **Expanding opportunities for practice** through practice exercises;
4. **Increasing learner engagement** through such things as video tutorials and games/gamification.

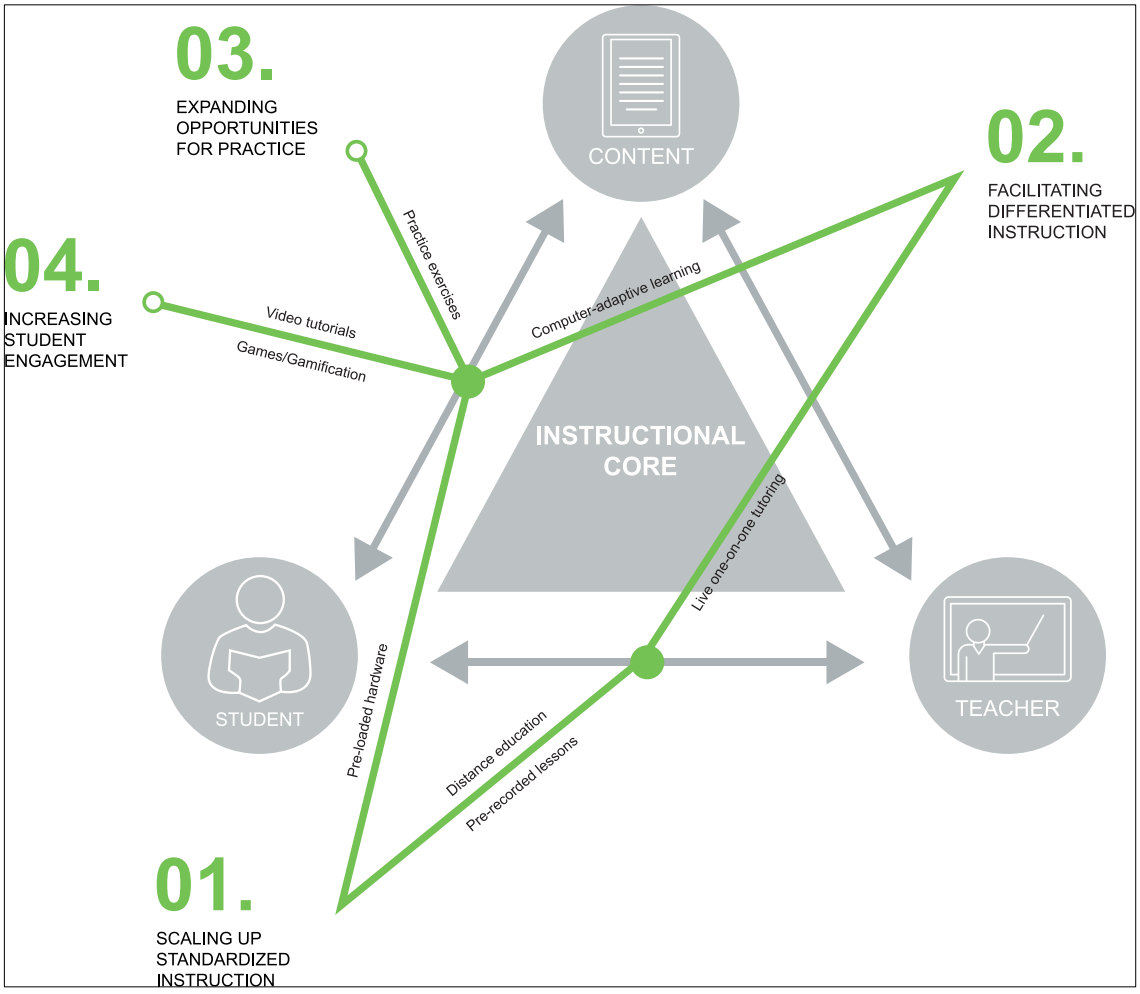

Figure 1: Comparative advantages of education technology (from: Ganimian et al, 2020, p. 29)

Research Questions

In order to further explore the four comparative advantages of technology and their application in the context of schools in remote Indigenous communities, this study focused on the following research questions:

1) How do the "four comparative advantages of technology" for student learning function and perform in schools in which digital interventions were used in remote Indigenous communities in Guatemala?
2) Are there additional comparative advantages or disadvantages that digital technology offers in schools in remote Indigenous communities in Guatemala?

Context and Intervention

The study examined the deployment and use of Mobile Learning Labs (MLLs) in ten schools in a project implemented by two Guatemalan and two Canadian not-for-profit organizations: AMMID, Mundo Posible, 60 Million Girls, and Change for Children. The intervention included ten schools: seven Primary Schools (Grades 1-6) and three Junior High Schools (Grades 7-9). The schools had a total of 1,638 students and 87 teachers in 2020.

The MLLs consisted of a RACHEL Plus 3.0 and a classroom set of tablets with keyboards. RACHEL (Remote Area Community Hotspot for Education and Learning) is a portable, battery-powered, device that contains open educational resources (OER) and websites, school curriculums, educational games, and various digital libraries. RACHEL wirelessly delivers (with a range of up to 35 metres) the content to tablets, laptops, or smartphones with no internet or data plans required. The MLLs are utilised off-line, however, content on the RACHEL can be updated by taking them to a place with internet connections and uploading new material programs from the Mundo Posible/World Possible website. This website provides a wealth of OER materials, teacher support, research and impact reports and sales information for the RACHEL system. Local users can upload their own materials, but they cannot modify existing files on RACHEL. The RACHELs deployed in this intervention contained the follow content: an off-line version of Wikipedia; Ka-Lite, a version of Khan Academy but for places without the internet; Guatemala Ministry of Education curriculum, modules, and textbooks; education materials produced in other countries such as Nicaragua, El Salvador, Panama, Mexico, and Educator; the Wikihow site; full Latin American Library; Great World Books, and many educational games and exercises.

Participating school and project staff received an initial full-day training on the operation, management, and maintenance of the equipment, followed by weekly school support visits from a pedagogy trainer and technical facilitator. Each school created a schedule for usage of the technology, with each teacher having access for two to five hours per week for use with their students depending on the size of the school. Teachers participated in virtual and in-person pedagogical training on a weekly-basis. They learned various ways to utilise the technology in their classrooms for instruction, practice, reference, and creative activities. With this support, teachers planned how to integrate the technology into their lessons. In addition, students had access to the equipment on their own for research, homework, or self-directed exploration.

While Guatemala has made significant progress in the last 25 years, major challenges exist in the drive towards inclusive and equitable quality education for all; notably geographic and gender inequalities, and the poor quality of much of the instruction. The urban-rural inequalities in terms of educational quality and completion rates are considerable, with drop-out rates higher in rural and Indigenous communities where students often leave school due to poverty. About 60% of Guatemalans live on less than US$4 per day, and 40% on less than US$2.5 per day. Of those living with poverty, 52% are Indigenous (World Bank, 2016).

An international comparative study (Ministerio de Educación, 2018) indicated that in Guatemala, student performance in reading and mathematics is among the lowest in Latin America, and one study (Ministerio de Educación, 2014) revealed that the majority of Grade 6 students in Guatemala did not pass national standardised achievement exams for math (56% failed) and language (60% failed). Inadequate teaching materials and resources and a lack of on-going teacher training and support, particularly in rural and Indigenous communities, are identified as the primary causes of these learning deficiencies (Naslund-Hadley et al., 2014).

The Municipality of Comitancillo, where this project was implemented, is typical of communities in western Guatemala. Comitancillo has a high population density with a population of 60,000 people, of which 99% identify as Mam, one of the 31 Maya ethnic groups in Guatemala. The local economy is based on subsistence and small-scale farming in this agriculturally-marginal mountainous terrain. Household economies are supplemented by labour migration within Guatemala and to other countries. Guatemala has the fourth highest rate of chronic malnutrition in the world and the highest in Latin America, with Indigenous and rural populations disproportionately affected. Chronic childhood malnutrition (and stunting) affects 58% of Indigenous children under the age of five (World Bank, 2021).

Primary schools function in about 80 rural communities in the municipality. There are junior high schools (Grades 7-9) in over 25 communities. There are nine high schools (Grades 10-12).

While an almost equal number of boys and girls attend school in Comitancillo, the drop-out rate is high. Of those completing primary school, only half continue on to junior high. Of those completing Grade 9, only 42% continue on to high school. The electricity grid has reached most areas of the municipality, however, there are still households without electricity (Prensa Libre, 2019). Most households now have a cell phone; however, mobile phone coverage is limited or unreliable because of sparse population and mountainous geography. Internet access in Comitancillo is poor, and in some communities, it is lacking completely. Comitancillo is located in the Department of San Marcos, one of the Departments in Guatemala with the highest poverty rates and the largest gap in internet access (Media Landscapes, 2018).

Methods

This study was conducted by a collaborative research team consisting of six local, school directors and educators and the advisory input of the local education supervisors from the Ministry of Education. A mixed methods approach utilising quantitative and qualitative data was employed to address the study's research questions. A quantitative study was conducted during the 2019 school year. This was complemented with qualitative data collected in focus group discussions, in-depth interviews, and systematic classroom observations in 2019 and 2020.

The quantitative component assessed student learning in mathematics and reading in Grades 6 and 7. Ten control schools were identified which had similar characteristics and contexts to the ten intervention schools (Figure 2). Pre- and post-tests for mathematics and reading performance were administered at the beginning of the school year in February 2019 and at the end of the school year in October 2019. The test data was analysed to determine any changes in student performance and whether there was a statistically significant difference between the intervention and control groups.

The total number of Grade 6 students was 512 in the 20 schools: 269 in the intervention schools and 243 in the control schools in 2019. A sample size of 200 students was selected, that is, a random sub-sample of 10 students (five girls and five boys) was selected from each of the 20 schools. A total of 193 students completed the pre-test and 192 students completed the post-test.

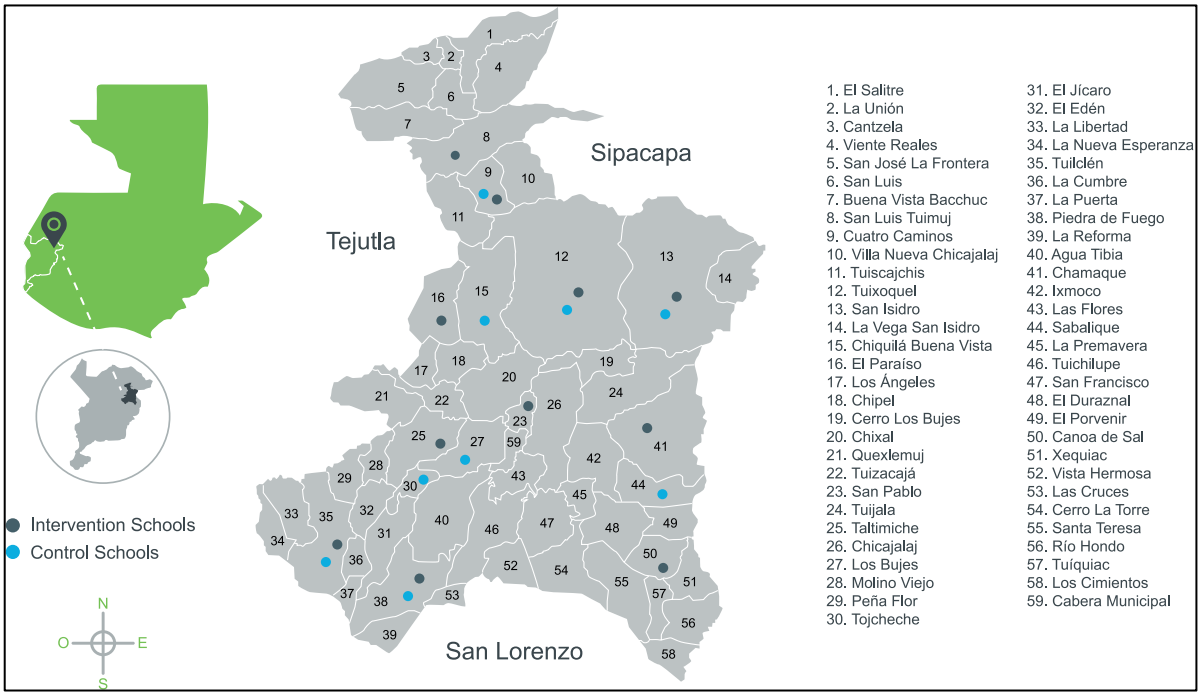

Figure 2: Study communities of Comitancillo, Guatemala

Standardised national tests of the Ministry of Education were used to evaluate student performance. The tests consisted of forty questions in each subject. The reading test measured knowledge, recall, usage, comprehension, and analysis. The math test measured probability, geometry, patterns, sets, fractions, decimals, percentages, and problem solving. The test results were graded manually and electronically, and the data was analysed using a statistical software program.

Qualitative data was collected through semi-structured individual interviews and focus group discussions conducted by native bilingual Spanish and Maya-Mam speakers in the first year in October, 20219. These interviews aimed to capture the perceptions of teachers and students about the effectiveness of the technology intervention focused on "six core investigative criteria (Situation Specificity, Cultural Sensitivity, Practical Usability, Theoretical Applicability, Economic Scalability, and Viable Sustainability)" (Kim, 2009, 416). An interview schedule was developed by the research team and two team members were trained to conduct the interviews and facilitate the focus groups discussions in Mam or Spanish. Transcripts were then analysed by the research team.

To delve more deeply into the perceptions and experiences of the student and teacher participants, a second phase of qualitative data collection was undertaken in June and July 2020. Semi-structured interviews were conducted with pedagogical advisors, school principals, teachers, and students of Grade 6 and 7. A stratified sample of 25 students, 10 teachers, and five school principals and administrators were selected from among the 10 intervention schools with 50% female and 50% male participants. In addition, interviews were conducted with three pedagogical advisors of the Ministry of Education. All quotes in the article are direct translations from Spanish into English of the transcripts. The first language of the teachers and students is Mam; Spanish is their second language and the primary language of education.

Findings and Discussion

Scaling up Standardised Instruction

Access through technology to high-quality standardised instruction and content has been shown to be particularly important for improving student learning in contexts "in which teachers have low levels of pedagogical and subject matter expertise" (Ganimian, et al., 2020, 31). The evidence from this study supports this evidence. In focus group discussions and in-depth interviews, both students and teachers reported that the instructional videos and audio files provided clear and accurate instruction of basic concepts, particularly for math, sciences and Spanish, and that these were used extensively in lessons. The Khan Academy instructional videos, in particular, were referenced by the majority (20/25) of students and all (10/10) of the teachers as effective tools for reinforcing student learning.

Both students and teachers reported that the audio and video lessons on the MLLs facilitated learning in a variety of ways. The recorded lessons enabled students to repeat the explanations if they did not understand something the first time. Recorded lessons overcome any deficiencies in the individual teachers' presentation of the topic. When questioned specifically about learning math and reading, 10/25 of students in individual interviews indicated that the MLLs helped explain and clarify concepts they had learned in class. The majority of students reported using the technology for instruction videos, explanatory exercises, and reinforcement exercises to strengthen math and reading skills.

This finding is consistent with other research evidence of the relative effectiveness of computer-assisted learning (CAL) and traditional teaching. A study in Sacatepéquez, Guatemala found that "combining technology with Khan Academy produces a higher positive effect on math performance… relative to the comparison group, the pilot intervention leads to an average increase of 10 points in math scores out of a possible score of 100 points" (Fundación Sergio Paiz Andrade, 2016). In Liberia, an evaluation of an afterschool program using Khan Academy mathematics programs found that while quantitative results after one year were mixed, there was evidence of generally more improvement in performance among the pilot group as compared to controlled student groups without access to the Khan Academy programs (Curtis & Kellerer, 2016).

Larger scale studies have also contributed to the evidence-base that teacher instruction augmented with computer math programs can result in improved student learning outcomes. Research evidence includes a randomised controlled trial of technology classrooms in primary schools in El Salvador (Büchel, et al., 2000), computer-assisted learning in schools for migrants in Beijing, China (Lai, et al., 2015), and an intervention of tablets with math software for primary students in Malawi (Pitchford, 2015).

Facilitating Differentiated Instruction

Teachers with low-levels of training, limited resources, and large class sizes often have difficulty meeting the unique learning needs of all their students. In both focus groups and individual interviews, teachers reported that the educational technology facilitated differentiated instruction adaptable to the specific needs of students. This included facilitating individually-paced learning, project-based learning, and using multiple methods to present and reinforce content. Teachers were able to use the MLLs to diversify their teaching strategies. With support from the project staff, the teachers learned ways to facilitate learning in groups, pairs, and individually, and to use videos, games, and project-based approaches to learning. In the focus groups, teachers indicated that this enabled students to work at their own pace and gave teachers an opportunity to provide additional support to those students who lagged behind.

Students also appreciated the variety of learning methods. The majority of students in the interviews (21/25) reported that the MLLs enabled diverse forms of organisation in the classroom, such as working in groups, pairs, or individually, which was rare previously. Numerous students highlighted the benefits of learning through visual and auditory means offered by the MLLs. In focus group discussions and individual interviews, students noted that the MLLs facilitated "learning by seeing," through videos, images, graphics, pictures, and games, "learning by hearing," through listening to books read aloud, to presentations, and to music, and "learning by doing," through practice exercises and interactive educational games.

Expanding Opportunities for Practice

Both students and teachers highlighted the extensive opportunities afforded by technology for additional "practice" of new subject matter (i.e., mathematical operations, reading vocabulary, and grammatical structures). The additional practice can be individually-paced and can reinforce new knowledge. Classroom observation by the research team before the intervention revealed that the majority of teaching was delivered in "chalk-and-talk" format which emphasises teacher exposition and student copying and memorising. Due to a shortage of textbooks and educational resource materials, students focus on copying information from the blackboard into their notebooks, and they may not have time to understand the new concepts being presented (Ganimian et al., 2020, 44). This is similar to research findings elsewhere in Latin America that indicate that traditional teaching practices based on teacher presentation, repetition, and memorisation continue to predominate in the region (Naslund-Hadley et al., 2014, 121).

During the intervention, project staff encouraged teachers to use the MLLs to offer students the opportunity to practice what they had learned in class so that students could confirm if they had understood correctly, and then practice the new skills or knowledge until they were confident in their learning. During in-depth interviews, students reported that the MLLs enabled them to practice and reinforce math and language concepts that they had learned in the class (16/25) and to better understand subject matter that had been presented in the class (9/25).

> When learning math and reading in Spanish, the RACHEL provided tools to practice what we learned… Using RACHEL, we practiced spelling words correctly, where to put punctuation, identifying numbers with denominators, heterogeneous and compound numbers. It helps us practice multiplication and division and analyze prime and composite numbers. – Student, Grade 7, Chamaque

> With RACHEL, the students individually or in pairs watch videos of how to carry out mathematical processes and they practice the different exercises. In reading, the students have the opportunity to read the same text [as in the video lesson], where the teacher puts into practice the guided reading, and also evaluates them with questions about each story or text. – Teacher, Villa Nueva Primary School

While teachers could have offered opportunities for students to do in-class practice without technology, the introduction of the MLLs was a catalyst for teachers to move away from lecture-dominated lessons, and to build in time for student practice.

Increasing Learner Engagement

It was clear that "learner engagement" not only involved more entertaining and interactive ways of learning (i.e., educational games and videos), but also more self-directed and autonomous opportunities propelled by individual student's interest. Both students and teachers highlighted the ways in which the MLLs motivated learning.

> I was very surprised when I heard about RACHEL. And, when it finally arrived in my little school, I was very happy. When I used it for the first time, it was very interesting and I learned a lot… It has been fun because it contains educational games and interesting videos. I confess that before we had RACHEL, classes were a little boring, but now with the presence of the technology, classes have become fascinating, very interesting, and more engaging. – Student, Grade 7, Taltimiche

> In the sixth-grade class, what is interesting is the interest and dedication of the students when working with RACHEL. When they realise that it is time to work with RACHEL, they jump for joy. When prompted to research a topic, they take the time and start browsing all over RACHEL. Everything is different when using RACHEL, because they enjoy working with technology. – Teacher, Cuatro Caminos Primary School

However, "learner engagement" went beyond just making learning "fun." In interviews, students indicated that the MLLs supported increased learner engagement in their own learning; not as much through games and video tutorials, as through the opportunity for self-directed learning (10/25) and enabling students to build self-confidence in their understanding of concepts and content (6/25). Unfortunately, one-quarter (6/25) of students noted that the MLLs were not used to increase learner engagement, but rather, were merely a substitute for traditional teacher lectures and hardcopy texts and worksheets.

> The content on RACHEL allows students to obtain more extensive knowledge; RACHEL presents several sources of information, facilitates many ways of learning, provides access to extensive content, and creates interest in children in their own learning. – Teacher, El Paraiso Primary School

Providing Free Access to High-Quality Educational Resources

Most obviously, the MLLs provide access to educational resources, libraries, and reference materials in schools and communities that have very limited resources and internet connectivity. Students had access to the technology an average of two to three hours per week. This was not just the replacement of print materials with digital materials, it was the first time many schools and communities had access to an extensive collection of high-quality educational resources and an enormous library.

The RACHELs used in this program contained the complete Guatemalan National Curriculum, as well as several Spanish digital libraries, and the equivalent of an off-line Wikipedia created by downloading various online resources and webpages in a PDF format and uploading them onto the RACHEL. The cost of access to this abundance of resources in rural, remote, and poor communities is made affordable by a digital off-line format rather than in a physical library or through connection to the world wide web. All teachers felt that the MLLs provided an excellent source of educational resources that they would not otherwise be able to offer their students. For students, learning to do research, synthesising and presenting information has been a valuable new opportunity. As noted above, there is cell phone signal available in most of the municipality, but internet connections are costly. In some communities there are "Internet cafes" with computers connected to the internet, and members of the public can pay to use the equipment, however, few students can afford more than quick 30-minute sessions.

> RACHEL is very important. With access to reference materials and the virtual library on RACHEL, we no longer have to do research on the Internet [go to town and pay to use a computer in an Internet café]. Being able to use RACHEL implies less economic expense. RACHEL contains all kinds of educational content, games, videos and everything that can help us learn so much. – Grade Seven Student, Taltimiche

Most Grade 6 and 7 students interviewed and those participating in the focus groups (16/25), stated that this was the greatest advantage of the MLLs. Students reported that before the intervention, they had to travel to the town centre of Comitancillo, which is up to two hours away from some villages, and then pay to utilise an internet café to research school assignments. For students from poor families, the free access to unlimited resources on the RACHEL was a tremendous benefit and could make the difference between continuing their schooling or dropping out of school. This finding corroborates research elsewhere which has documented the cost-effectiveness of computers over print textbooks for provision of classroom learning content, in cases where more than three textbooks were substituted with digital versions (Bando et al., 2017). In the Comitancillo case, complete textbook sets for all subjects and all grades, as well as extensive libraries were made available on the MLLs.

Building Teacher Capacity

Teachers highlighted three ways that the MLLs improved the quality of their teaching: 1) diversifying their teaching strategies, 2) strengthening their own grasp of the subject matter, and 3) standardising instruction.

> It is a great library that allows us to better prepare classes, investigate, facilitate processes through manipulation, and stimulate the interest of students. – Teacher, Tuixoquel Junior High

Similarly, the in-depth interviews with School Principals confirmed that the primary benefits of the technology for teachers were: 1) they gained skills and confidence with the technology, 2) they had access to a wealth of educational resources, and 3) they learned new teaching strategies.

Most teachers have very limited previous experience with technology. While many have cell phones, most do not have smartphones, laptops, or computers. Few have experience with using technology for research or educational purposes. While younger teachers are often more familiar with using technology, most older teachers have no experience. There is currently no support for teacher capacity-building in the use of technology by the Ministry of Education, either in basic teacher

training or in ongoing professional development programs. Thus, firstly, teachers need instruction in the use and maintenance of the equipment before they can effectively use it with their students.

Once teachers were somewhat comfortable and confident in their use of the equipment, they began to utilise the technological resources to improve their pedagogy practice. The RACHELs were useful to teachers for preparing lesson plans and enabled them to ensure that they had accurate information to share with their students. They explored the virtual library to get more information for their lessons on subjects such as: mathematics, biology, language arts, and English language instruction.

> Sometimes, I do not have all the information in the national curriculum for a topic that I have to teach to my students. Before I would be scrambling to find any information I could from friends, or other teachers. Now, I can look up additional information or explanations, and I can be sure that the information I share with my students is accurate. – Teacher, Tuixoquel Junior High School

The project also included project staff support and materials on the RACHELs for teachers to learn new teaching strategies such as: project-based learning, comparative charts, concept maps, and individual inquiry-based learning. Both teachers and student reports, as well as classroom observation, indicated that there was an increased variation in the pedagogy strategies utilised in the classroom as a result of these training sessions.

Developing Digital Literacy

Learning to use technology was a very important outcome of the project for both teachers and students. The most recent data available from UNESCO (2013) indicates that in Guatemala more than 50% of households do not have a computer or internet connection, and this is estimated to be about 80% in rural and remote areas.

For the majority of the total number of participating teachers in the intervention schools (63% - 95/150), this was the first time they had opportunity to use this type of technology. Similarly, for most of the total number of participating students (70% - 1260/1800), this was the first time they had the opportunity to use educational technology, to learn to operate a tablet and to perform basic computer operations. The remainder of students indicated that they some limited experience, mostly with cell phones, and during the project their abilities advanced in searching the databases and utilising various applications.

> I couldn't even turn on a tablet before RACHEL arrived. But now I know how to turn on a tablet, navigate RACHEL, download a book, and do exercises. With the tablets I have learned many things that I did not know. Now, classes are more fun. Above all, RACHEL has taught me to love reading books. – Student, Grade 6, Cuatro Caminos Primary School

> Something that always impresses me is to see how students who do not even have a smart cell phone, immediately acquire the ability to turn on the tablet with RACHEL, enter and look for what the teacher tells them. This does not happen when students are asked to research something in physical textbooks. This shows that students have a great curiosity to get into the use of technology, which at the same time is becoming a necessity for the development of humanity. – School Principal, Canoa de Sal Tele-Secondary School

Use of the MLLs in remote communities without internet connectivity will not overcome the first level of the digital divide, that is the physical connection to the digital world through the internet.

However, MLLs do facilitate reduction of the second aspect of the first level of the digital divide, that is material access, which includes computer devices, software, maintenance, and peripheral equipment (Van Deursen, et al., 2019). In addition, MLLs in the classroom provided opportunity to increase the digital literacy of teachers and students, that is the technical and cognitive skills to use information and communication technologies, that relates to the second level of the digital divide. Thus, while the physical divide is not yet bridged, provision of off-line educational resources in the form of MLLs provides the opportunity to reduce the gaps in material access and it is possible for teachers and students to begin to overcome material and skills barriers to the digital world — an imperative for young people entering the work force. Those who cannot use it confidently, whether communities, teachers, or students, will become increasingly marginalised (social exclusion) within the modern world.

Digital literacy not only improves access to higher quality educational materials, it is also a door to increased opportunity. Digital literacy was not an element included in the original theoretical model (Figure 1), however, we found that it is an essential component without which none of the proposed benefits of technology use are not possible. Digital capacity-building needs to be intentionally integrated into all education technologically-based initiatives. For marginalised communities in the Global South, these experiences and skills are vital for young people's ability to survive and thrive in the globalised world.

Integrating Family, Community, and Cultural Perspectives

An additional element, not highlighted in the original theoretical model, is the role of the students' families and communities in the relationships and interactions within the instructional core model. The Maya-Mam social and cultural context of the remote communities in Comitancillo is particularly pervasive and cohesive despite outside influences. The educational technology used here showed potential to be a tool for increased family and community engagement in the education of young people.

Family and community support for education is critical to the success of students, especially those in Indigenous communities. According to a recent study of Indigenous communities in Canada, New Zealand, and Australia, the three key elements to improve Indigenous education are: 1) quality and effectiveness of teaching; 2) active engagement of families and communities in students' education; and 3) provision of direct support to students (OECD, 2017).

Technology in the classroom in Comitancillo not only generated motivation among the students to learn, but it also increased the interest of parents in their children's education, as reported by project staff:

> The implementation of the MLLs in the schools motivated the parents to accompany and ensure the training of their sons and daughters by making constant visits to the establishments to verify the progress of the use of technology by the students in the classrooms… In the intervention schools, parents contributed with the purchase of materials to protect the technological equipment and strengthen security in the classrooms. – Project Staff Member

Parental interest in the educational technology seems to stem from several factors: their desire for their children to be able to compete in the wider world where digital knowledge and skills are a

requirement, their hope that new and innovative investments in the local school will improve the quality of education, and their desire to ensure that this new initiative is a success.

Community Cultural and Linguistic Content

Potential uses of technology to capture and share traditional Indigenous cultural knowledge through audio, visual, and interactive means have not yet been extensively investigated. Studies of Indigenous education have identified the need for 'decolonising' learning processes and content and strengthening gender-equitable perspectives (Munroe, 2013; UN, 2010). This includes respecting Indigenous knowledge and its unique approaches to learning, respecting Indigenous holistic vision/perspectives, integrating Indigenous and local community content, and reducing gender-based barriers to education. Research in Latin American Indigenous education programs highlights the importance of upgrading educational resources and teacher capacity, and the need for engagement of families, communities, and social movements related to human rights, cultural identity, and respect for diversity to provide the context in which Indigenous education can flourish (Cortina, 2017; Lopez, 2014).

Evidence from studies of the Guatemalan Bilingual-Intercultural Education Program demonstrates similar findings (USAID, 2013). The Government of Guatemala has been committed to high-quality bilingual/intercultural education for more than 40 years, however, given the diversity of cultural and language groups, it has been a challenge to achieve this goal for speakers of the twenty-one Mayan languages in Guatemala. Mam, the language spoken in Comitancillo, is the fourth largest linguistic group in Guatemala, with 500,000 speakers. Many of the students in the rural communities start school speaking only Mam, and they begin to learn Spanish during primary school. Comitancillo has the highest percentage of Maya-Mam teachers of Municipalities in Guatemala. In the early 1990s, less than 10% of the teachers in Comitancillo were Maya-Mam speakers. Today, 570 teachers of the total 597 (95%) government employed teachers in Comitancillo are Maya-Mam (Ministry of Education, 2016). Despite this, there is a lack of resource materials for teaching Mam language and culture.

The MLLs offer the opportunity for teachers, students, and community members to create, upload and share open education resources (OER) for teaching Mam language and culture. During the project, a total of 134 documents and educational resources of culturally and linguisticaly-specific Maya-Mam content, including language learning materials, information on local culture and history, and research studies on the community were uploaded to RACHEL servers.

Teachers received about two hours of instruction on the Mam materials and potential ways of using these. All teachers reported using the new content, particularly for teaching Mam reading and writing. Teachers in younger grades especially liked the printable words in Mam and Spanish which they could place around the classroom on various objects. Junior high teachers appreciated the reference information about their own community, such as research studies on various social, economic, and cultural aspects of Comitancillo.

Teachers and students noted that the Mam materials were relevant and of good quality. However, at present, they are all un-editable PDF documents. In the future, teachers and students would like to experiment making additional video and audio recordings, as well as creating more interactive educational materials.

Student Learning Outcomes: The Data

As noted, a sample of 192 students completed pre- and post-tests, 50% from intervention schools and 50% from comparable control schools. The tests administered were the Official Grade 6 national exams of the Ministry of Education for assessing reading and mathematics learning based on the National Curriculum.

Table 1 outlines the results of the pre and post-tests, demonstrating a lack of statistically significant differences between the two groups, with a Confidence Level of 95%. In fact, in mathematics, both grades in the control schools showed greater improvement over the nine-month period than the intervention schools. Only in the Grade 7 Reading test did the students in intervention schools show a greater and statistically significant improvement over the students in the control schools.

Table 1: Average percentage scores on pre- and post-texts

	Reading Spanish			Mathematics		
Average (Mean) Score	Pre-test	Post-test	Difference	Pre-test	Post-test	Difference
Gr. 6 Intervention Schools	32.89	32.06	-0.83	29.38	29.92	+0.55
Gr. 6 Control Schools	29.32	28.57	-0.75	21.25	24.79	+3.54
Gr. 7 Intervention Schools	29.40	34.08	+4.58	31.67	33.42	+1.75
Gr. 7 Control Schools	30.95	33.88	+2.93	28.2	31.12	+3.10

Two observations are necessary when assessing these disappointing results: one related to the length of the study, and the second related to the national educational context.

The length of the study was not sufficient to demonstrate a significant change in student learning outcomes. School closures in March 2020 due to the global pandemic shortened the study from two years (2019-2020), to only one school year (nine months) of classes.

The results are similar to those found in other studies. A 2018 study elsewhere in Guatemala of student performance after one year of implementation of MLLs similar to the ones in this intervention showed improved performance of students with access to technology at a rate that was statistically significant but not to a level of 95% confidence (Centro de Investigaciones Educativas, 2018). Additionally, a large-scale randomised evaluation of the One Laptop per Child program in Peru was conducted in 2011, using data collected after only 15 months of implementation in 319 primary schools in rural areas of the country (Cristia et al., 2012). "The results indicate that the program increased the ratio of computers per student from 0.12 to 1.18 in treatment schools. This expansion in access translated into substantial increases in use both at school and at home. No evidence is found of effects on enrollment and test scores in Math and Language." (4). However, the study did find some positive effects in general cognitive abilities that suggested advantages and potentially longer-term impacts if students and teachers have the proper training and support.

The second observation is the overall low scores. These Comitancillo students scored between 28% and 34% on national exams on which they would ideally be scoring marks over 60% at the end of the school year. These low scores are comparable to national averages which show that only 29% of students passed the Grade 6 reading exams, and 45% passed the math exams (CONADUR, 2017), reflecting the generally poor quality of education in Guatemala.

Conclusions

We conclude by returning to the research questions that guided this study.

1) How do the "four comparative advantages of technology" (Ganimian et al., 2020) for student learning function and perform in schools in marginalised Indigenous communities in Guatemala?

   Despite the shortened length of the project due to school closures as a result of the COVID-19 pandemic, the research findings corroborated and further nuanced the four comparative advantages of education technology identified in the Brookings review (Ganimian et al., 2020). In this Guatemalan study, the technology was found to: 1) increase standardised instruction particularly through the use of instructional videos; 2) facilitate differentiated instruction through opportunities for individual learning; 3) expand opportunities for practice especially in the use of learning games and exercises to reinforce new subject matter; and 4) increase learner engagement as a result of interactive and self-directed learning opportunities.

2) Are there additional advantages that technology can offer in schools in marginalised Indigenous communities in Guatemala?

   The study provided evidence of four potential additional advantages or key intervention points where technology can improve student learning in marginalised Indigenous communities. These are: 5) free access to high-quality resources, 6) teacher capacity-building, 7) student learning to use technology, and 8) developing and sharing family, community, and cultural knowledge and engagement (Figure 3).

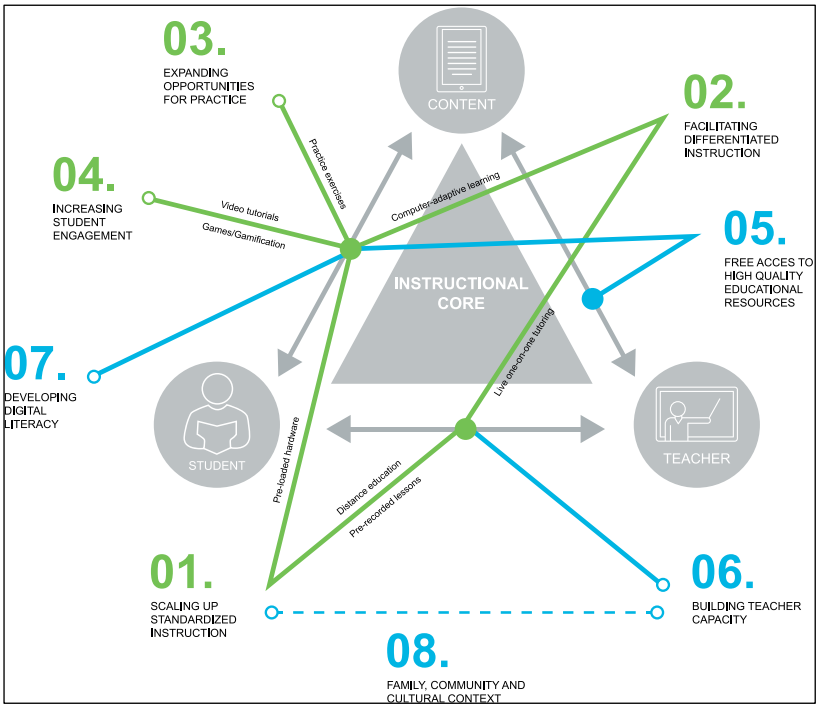

Figure 3: Theoretical Model with findings from Guatemala Project (blue)

While these additional advantages, such as free access to resources and development of digital literacy, may seem obvious or immaterial in many global contexts, for marginal Indigenous

communities, these are potentially ground-breaking and transformative. These elements need to be identified, highlighted and intentionally developed in theoretical models and in the implementation of *other* educational technology enhanced programs.

Recommendations for a next stage of implementation of MLLs in the classroom are:

- Offer more and ongoing training for teachers on how to integrate technology into their lessons in creative and engaging ways that are student-centered;
- Include intentional training for students on how to use and manage both hardware and software to build digital and technological knowledge and skills;
- Extend after-school opportunities for students to use the technology for homework assignments, research and personal interest;
- Develop student and community ability to create and share more community and cultural educational resources;
- Work closely with local, regional, and national education authorities to develop and implement technology programs so that initiatives are sustainable and closely integrated into national planning and curriculums.

Recommendations for Further Research

- Utilise both context-specific learning outcome evaluations in addition to standardised national tests to assess student learning results;
- Investigate further the differential experiences of girls and boys, teachers and administrators, and according to grade level in the impact of technology use;
- Undertake a longitudinal study which follows the experience and learning results over the course of at least three-years of full implementation.

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